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ABSTRACT

Questionnaires were sent to all of the medical, dental, veterinary, and public health schools in the United States and to selected degree-granting U.S. schools of nursing, medical technology, and pharmacy. The data collected included type of biological prerequisites for each school and role of preparatory courses in the admissions policy. A comparison was made among the six types of schools and between different groups within the dental and medical faculties. (MH)

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Biological Prerequisites For Education in the Health Sciences

A CUEBS Position Paper

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PREFACE

Sequentially-based professional programs which are premised on interdigitation but move independently, are justifiably subject to the age-old criticism about the right hand not knowing what the left is doing. The unplanned and needless redundancy that results from this lack of awareness lead to inefficient utilization of human and physical resources. On the one hand, the undergraduate college uncritically requires a student's time and attention to a course of study out-of-date with the expectation of the professional school; on the other hand, the professional school blithely replows already thoroughly tilled subject matter.

In an effort to foreshorten the information gap on preprofessional preparation, and in this particular instance the major health professions, this report is submitted for consideration. It provides considerable information on the similarities and differences in expectation of preprofessional training for the several health professions. In consequence, there are ample implications regarding the preprofessional experience — where it should start and what it should be. The distance between these points is sufficient to hope that this study will initiate reassessment of programs at both the preprofessional and professional training levels. With this expectation in mind, the publication will be widely distributed and, we trust, discussed both within and between each training level.

Not atypically, this report contains implications broader than the health professions or undergraduate biology *per se*. For example, one can sense the need for a more comprehensive study of preprofessional preparation for the medical sciences, especially regarding the physical and social sciences; to my knowledge, no such plans are projected. In addition, one can see that current cognate science preparation for the research degree in biology needs careful scrutiny; such a study will shortly be undertaken by CUEBS.

On behalf of those who will be most immediately served by this report, the Commission expresses its gratitude to Dr. Roos for his work in preparing this document and for chairing the panel which directed the study. We also acknowledge, with thanks, the panel members and the many respondents without whose cooperation the study would not have been possible.

Edward J. Kormondy
Director, CUEBS
May, 1969

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Thomas B. Roos
Chairman, Panel on Preprofessional
Training for the Medical Sciences
November, 1968

Rapid increases in the quantity of biological information and the quality of understanding that this increase allows have induced sweeping changes in biology courses and curricula. These changes are occurring at all levels, but their most immediate effects have been in high school biology courses (Herron, in press) and undergraduate biology major programs (CUEBS, 1967). Although the new programs are themselves desirable, they have emphasized the lack of understanding among members of the various faculties responsible for different aspects of health science education. It has long been noted (Whewell, 1873) that adding new knowledge to old requires new types of presentation. Faced with a burst of information, traditional curricular change, with its proliferation of courses, multiplication of prerequisites and extension of training time, is inadequate. Classical explanations must instead be altered, and new, more expeditious approaches be devised. There is now a shift in biological education from the forms familiar to college and professional school biologists towards new forms. These not only differ from the established pattern, but vary among institutions. The Commission on Undergraduate Education in the Biological Sciences (CUEBS) has recently examined some of these new curricula (CUEBS, 1967).

The Commission also established a panel to study the biological component of preprofessional education for the various health sciences. This panel has seen as its purpose the identification of those areas within the general field of biology that are prerequisite to study in one of the health sciences. We have tried to make judgements that are independent of traditional course organization and titles. The health fields surveyed included those granting advanced degrees (human, veterinary, dental medicine and public health) and baccalaureate degrees (nursing, pharmacy and medical technology). Non-degree programs (certificate or associate studies) were not surveyed. A questionnaire (Figure 1)* was devised to elicit information from the respondent on the training and curricular change at his institution, and on the biological information needed to teach his discipline.

The heart of the questionnaire was the Biological Information Grid (Figure 1B). Traditional terms for "preprofessional courses" were eschewed, partly to avoid stereotyped responses and partly to reflect changes in college teaching. Biology was divided into ten levels of organization, ranging from *Atoms* (1) to *Populations* (10). This general arrangement often has been used in recent years to describe the systems with which biologists work (Roos, 1965; Grobstein, 1964). The terms *Atoms* and *Molecules* are self-explanatory. *Macromolecules* represents the level of polymeric compounds, whose properties derive both from the linear order of their subunits and from the spatial arrangement of the entire molecule. *Macromolecular Aggre-*

gates includes those temporary structures formed by co- or adhesion of macromolecules or of macromolecules with large numbers of smaller molecules. All of these levels include at least some of the material from courses in physics, chemistry, biochemistry, physiology, biophysics and molecular biology, and some parts of the areas of developmental biology and genetics (Figure 2). *Organelles* includes more permanent cellular components and derivatives; the term *Cells* is self-explanatory. The level of *Cellular Aggregates* includes both homogeneous and heterogeneous accumulations, whether in the form of tissues and organs or of undifferentiated or specialized colonies; the dividing line from individuals or even aggregates of individuals can thus become obscure. These two levels (*Cells* and *Cellular Aggregates*) include much material from traditional genetics, morphology, histology, and cytology, physiology, biochemistry, development, and endocrinology. The *Individual* level is again self-explanatory and encompasses almost every traditional biological subdiscipline. *Aggregates of Individuals* may be either heterogeneous (e.g. feeding communities or symbiotic partnerships) or homogeneous (e.g. breeding communities or colonies) but is meant to include only groups of organisms which actually interact. *Populations and Larger Associations* could easily be fractionated into traditional taxon levels, up to and including the biosphere, but is meant to indicate all possible interactions among individuals.

Three sets of viewpoints were used within the grid to distinguish between different ways of grouping material at each level. In the first (*Energetics - Information*). *Energetics* and *Information* constitute two organizing principles for the facts of biological regulation and metabolism. Depending on the level, *Energetics* might include high-energy trapping, energy storage, nutrition, or food chains. Similarly, *Information* could be that contained in protein primary structure, messenger RNA, cell recognition factors, human language or mating rituals. The second viewpoint (*Technical - Descriptive*) is more pragmatic and includes *Methods and Skills* and *Structural Diversity*. The first category is self-explanatory, and the second represents the comparative and systematic approach necessary to order the mass of diverse biological data. Both are again applicable at all levels and include aspects of many traditional areas (Figure 2). The third set of viewpoints includes four time-related frames of reference: *Development, Adaptation, Integration, and Proliferation*. *Development* covers the life span of the observed system. *Adaptation* represents the permanent changes introduced into the system as a result of an internal or external stimulus; this would include altered development, physiologic adaptation or modified population composition. *Integration* includes the transitory changes that maintain the system in a steady-state balance (homeostasis). *Proliferation* subsumes both replacement of one system by its successor by descent and multiplication in the total number of systems.

*Figures start on page 15.

METHODS

I. Questionnaire.

Questionnaires were distributed to the deans of all of medical, dental, veterinary and public health schools in the United States and to the deans of selected, degree-granting U.S. schools of nursing, medical technology and pharmacy. Each dean was requested to direct copies to appropriate faculty members, including those with responsibilities for admissions and for teaching in basic and clinical areas. Ten questionnaires were sent to each medical school and four to each other type of school; schools which returned questionnaires are listed in Appendix A.

Data from these questionnaires, completed according to the printed instructions (Figure 1A), were transcribed to punch cards for tabulation and analysis. The scale of responses for each cell (intercept) in the Biological Information Grid was intended to provide a guide to the value of that material in preparing students for professional study.

II. Analysis of responses to the Biological Information Grid.

The five categories of response in the rating scale (Figure 1) were reduced to the following four by omitting choice "E" from further consideration:

- a. Truly prerequisite material, including that required for use in professional training and especially that required by the respondent in teaching.
- b. Information highly desirable for background, but not required for professional training.
- c. Material best considered during, rather than before, specific professional instruction.
- d. Material irrelevant to professional specialization.

These four choices were then reduced to a single index value, R, for each cell in the matrix. This facilitated comparing the importance of various biological segments to professional study in each health science.

Totaled responses for each category were weighted before computing R (the index of preprofessional importance). Choices "B" and "D" received unit value; an opinion of desirability thus received equal weight to one of irrelevance. Choice "C" was given double weight because of the possibilities that the order of presentation is often as important as the facts presented and previous exposure is sometimes undesirable. Areas deemed truly prerequisite got further weight, since material presumed by some teachers to be known is better repeated than omitted. Therefore

choice "A" responses were weighted twice the value of "C" (i.e., four times "B" or "D"). The index was calculated as the ratio of weighted responses favorable to preprofessional coverage to those unfavorable as follows:

$$R = \frac{4A + B}{2C + D} - 1$$

The constant, one, was subtracted in order to render negative all weighted ratios in which unfavorable responses exceeded favorable ones.

Values of R less than 0 were felt to indicate areas that could or should be omitted from preprofessional education. Values between 0 and 1 signified neutral information, while values greater than 1 identified material desirable in preparation for the study of the health sciences.

III. Comparisons between types of schools.

Indices were computed for each cell in the Biological Information Grid according to the responses from the following types of schools:

1. Dental Medicine
2. Medicine
3. Veterinary Medicine
4. Medical Technology
5. Nursing
6. Pharmacy

The schools were compared by intercept in the grid, levels of organization and viewpoints, using $R > 1$ as evidence for desirability for preparation and $R < 0$ as evidence for undesirability. The number of cells in which $R > 1$ was compared among the different schools in order to measure the relative importance of a particular level or viewpoint.

Data were also grouped to compare the responses of faculties in doctorate with baccalaureate degree-granting schools. Responses of dental and medical school faculties were pooled and re-sorted to allow comparisons of degrees granted before and after 1950, of professional and research degrees and of basic and clinical departmental affiliations.

The magnitude of the R-value was ignored, except as an indicator of "desirability" ($R > 1$) or "undesirability" ($R < 0$). It was felt that the number's size might not be a reliable measure of the relative importance among areas desirable for preparation. Furthermore, the values bore no relation to the amount of time needed for adequate presentation. The lack of reported statistical relationships is also an attempt to underline the qualitative nature of the identification of desirable areas.

Final comparison between different school types was based on the percent actual identity vs. possible identity in response (concordance). Thus, in the case of medical and dental schools, there were 29 cells in which $R > 1$ for medical schools and 40 cells in which $R > 1$ for dental schools; 29 was the maximum possible identical response.

Only 27 of the 29 medical school intercepts where $R > 1$ match the dental school responses, however, leading to a concordance of 93 per cent (Table 6A). Responses were thus compared for $R > 3$, $R > 1$ and $R > 0$, and rankings of similarity in response were constructed by averaging the three values (Table 6B).

I. Nature of the respondents.

Completed questionnaires were returned by 564 persons, representing 103 different institutions. Six types of schools provided 96 percent of the answers, as shown in Table 1. The preponderance of medical school responses largely reflects the distribution of questionnaires (Appendix A).

TABLE 1. SOURCE OF QUESTIONNAIRE RETURNS		
Type of School	Number of Respondents	Number of Schools
Dental	105	41
Medical	224	65
Veterinary	46	15
Medical Technology	27	18
Nursing	43	27
Pharmacy	85	45
Other	34	16
Total Doctorate	375	121
Total Baccalaureate	189	106
TOTAL	564	227

The responses within the medical and dental categories were sorted to identify the activity of the respondent within his school and the nature and date of his doctoral degree (Table 2). Further sorting of the biographical material yielded the list of departments shown in Appendix B. There was almost even division between those respondents who had received their degrees before and

TABLE 2.
STATUS OF RESPONDENTS

General Status	Dental	Medical	Total
Dean	3	13	16
Clinical Faculty	54	58	112
Basic Science Faculty	54	152	206
Professional Degree	48	77	125
PhD	31	110	141
Both	22	18	40
Degree before 1950	32	118	150
Degree 1950-1959	43	76	156
Degree since 1960	26	11	

after 1950. Only small differences of opinion were evident between respondents with professional (MD, DDS, etc.) and research (PhD) degrees (cf. Discussion).

II. Preparatory courses and professional school admission

Most respondents anticipated imminent curricular changes within their professional schools but did not expect a concomitant change in admissions policies (Table 3). New curricula seem most likely to be developed in doctoral-level schools, where the question, "Is your school planning any extensive curricular revision in the near future that might take advantage of recent changes in undergraduate biology preparation?" was answered affirmatively in 52 percent of the questionnaires. (In an independent

TABLE 3.
PROSPECTS FOR CURRICULUM AND ADMISSION CHANGES

A. Prospects for curricular revision in response to changes in undergraduate biology preparation.			
	% Affirmative	% Answering	N**
Doctoral-level schools	52	76	375
Baccalaureate schools	34	85	176
B. Prospects for revised admission requirements.			
	% Affirmative	% Answering	N
Doctoral-level schools	26*	70	375
Baccalaureate schools	15	84	158

* Veterinary Schools faculties answered 39 percent affirmatively.

** Number of respondents.

study of medical schools, 54 percent of the schools involved responded similarly [Littlemeyer, in press]). Only 35 percent of respondents from baccalaureate-level institutions answered "yes." A similar dichotomy occurred in response to the question, "Is your school planning any revised admission requirements?", although the total number of

affirmative answers was only about half as great as to the preceding question (Table 3).

Most respondents believed that the chief value of required courses is to prepare students for professional training, rather than to serve as a guide to admissions committees (Table 4). Twice as many faculty members in

TABLE 4
PREREQUISITE COURSES

A. Prerequisites for Professional School Admission

1. Doctoral-level Schools

School Type	Biology ^a	Comp. Anatomy	Embryology	Genetics	Other
a. Dental*	51	4 (8) ^b	3 (2)	1 (4)	2 ^c (2) ^c
b. Medical**	99	5 (17)	13 (23)	9 (26)	2 ^d (6) ^e
c. Veterinary***	15	3 (7)	5 (5)	7 (5)	7 (2)

2. Baccalaureate Schools****

School Type	Biology ^a	Comp. Anatomy	Embryology	Genetics	Other
a. Medical Technology	32 (35) ^b	11 (35)	32 (39)	11 (46)	32 (35)
b. Nursing	56 (7)	26 (14)	16 (23)	14 (42)	56 (2)
c. Pharmacy	96 (0)	24 (20)	4 (21)	2 (31)	73 (6)

B. Value of Prerequisite Courses

	Doctoral-level	Baccalaureate level
1. Index of success in professional school	26%	14%
2. Index of success in practice	1	3
3. Preparation for professional school	70	81
4. Other	3	2

C. Desire to replace existing course requirements by a comprehensive examination.

	Yes	No
1. All except Nursing	31%	63%
2. Nursing Schools	47	53

* Admission Requirements of American Dental Schools, 1968-69.
American Association of Dental Schools, Chicago, 1967.

** Medical School Admission Requirements, 1967-68. Association of American Medical Colleges, Evanston, 1967.

*** Summarized from Catalog Listings, 1968.

**** Determined by Responses to the Questionnaire.

a) One year, two semesters, three quarters; assumed to be at least 1/2 zoology.

b) Values in parentheses show number of schools for which the course is recommended.

c) Physiology (1), Anthropology (1), "major course" (2).

d) Cell or Molecular Biology (1), Developmental Biology (1).

e) Physiology (2), Histology, Vertebrate Structure and Function, Ecology, and Natural History (1 each).

doctoral-level as in baccalaureate-level schools felt that the major use of required courses was to provide an index to performance in professional training; as will be seen below, this feeling reflected views on the amount of material required for adequate preparation. A sizable minority of all respondents (32 percent) answered yes to the question, "Would you favor replacing existing course requirements by satisfactory performance on an achievement examination...?" The positive response to this question was especially high among teachers in schools of nursing (Table 4).

III. Desirable biological preparation for the health sciences.

A. Total Response. Raw data accumulated from the questionnaires is given in Appendix C. The figures (Figures 5-10) and tables (Tables 5 and 6) treat only index values, as determined by the method given above. The unshaded boxes in Figures 3 thru 13 signify R values exceeding unity.

When the total response is examined, 44 of the possible 80 cells in the Biological Information Grid are seen to have R values greater than 1 (Figure 3). Fifteen of these represent the Energetics-Information viewpoint, 23 the Time-Related viewpoint, and only six the Technical-Descriptive viewpoint. In terms of levels of organization, 34 are at cytological or higher levels and the remainder are at molecular levels.

Since the number of respondents from different faculties was unequal (Table 1), the indices for the entire sample were also calculated after weighting each school inversely to its proportionate share of the total response. Figure 4 shows those areas in which R exceeded 1 when thus recomputed. The number of "desirable" areas is diminished to 34, with the major reduction occurring in the Energetics-Information viewpoint. The balance between molecular and higher levels of organization shifted strongly in the direction of molecular studies (38 percent as compared with 23 percent).

B. Schools of Dental Medicine. Half of the possible grid intercepts (Table 5A and Figure 5) were cited as "desirable" ($R > 1$) and only 10 as "undesirable" ($R < 0$). Most of the intercepts identified as being desirable are at cytological levels and higher or are related to the process of protein synthesis.

Some intercepts (7) in the Technical-Descriptive viewpoint were called desirable, but an equal number were considered undesirable. The greatest uniformity in response was at the individual and atomic levels and in the Technical-Descriptive viewpoints (Table 5B).

C. Schools of Medicine. Most of the 29 areas desirable for preparation are at cytological through individual levels and avoid specific technical training (Table 5A and Figure 6). Indeed, 7 of the 10 "undesirable" areas are of the Technical-Descriptive viewpoint. The predominant

Time-related areas cited are in Development, Adaptation, and Proliferation. There was highest agreement among responses at the individual, cellular and atomic levels, and in the Technical-Descriptive viewpoint (Table 5B).

D. Schools of Veterinary Medicine. Emphasis on biological preparation is skewed towards the higher levels of organization, with 21 of the 43 "desirable" intercepts at the population, aggregates of individuals, or individual levels (Table 5A and Figure 7). The responses showed preferences for theoretical and process-oriented approaches, rather than descriptive and technical ones (Table 5A). There is strong opposition to including material at the macromolecular aggregate level in preparation for professional school; 4 of the 5 "undesirable" intercepts are at this level, and agreement among respondents was generally high (Table 5B).

E. Schools of Medical Technology. Most of biology is considered desirable preparation, especially theoretical and technical-descriptive material (Table 5A and Figure 8). There is apparent antipathy towards preparation in population-level biology, since 6 of the 13 "undesirable" intercepts are at this level. Again, agreement among the different respondents was high (Table 5B).

F. Schools of Nursing. Almost all of biology except its technical-descriptive aspects was cited as desirable (Table 5A and Figure 9). More than 80 percent of the possible intercepts in the Theoretical and Time-related viewpoints had values of $R > 1$. Most of the intercepts in the Technical-Descriptive viewpoint are considered "undesirable" (9 of a possible 20); only 8 are considered "desirable." There was good agreement among the answers to the questionnaire (Table 5B).

G. Schools of Pharmacy. General preparation in biology, except for its techniques, is considered "desirable" (Table 5A and Figure 10). On the other hand, specifically technical material is held to be "undesirable" at 4 of the 10 levels and "desirable" at only 2. Agreement among the respondents was greatest in the middle levels and for a theoretical viewpoint (Table 5B).

IV. Comparison among faculties in the six types of schools.

Since each type of school has different faculty and student interests and professional aims, it is perhaps surprising to find as much agreement between school types as is evident (Figures 11 and 12). Seven of the 20 intercepts in the Energetics-Information category were identified as "desirable" ($R > 1$) by all six school types. Similarly, 3 of the 20 Technical-Descriptive intercepts and 9 of the 40 Time-related intercepts were called "desirable" for preparation. Agreement by levels of organization was even more striking. Out of the 19 common intercepts, 5 were at the individual level and 18 bracketed the "organismic"

TABLE 5.
RESPONSES ACCORDING TO ORGANIZATIONAL LEVELS OF BIOLOGY

A. Number of Intercepts where $R > 1$

		Dental	Med.	Vet. Med.	M. Tech.	Nurs.	Pharm.
Total	(80)	40	29	43	57	58	55
Level							
Populations & Larger Assocs.	(8)	3	1	7	1	4	3
Aggregates & Individuals	(8)	5	3	7	3	7	5
Individuals	(8)	7	6	7	6	7	7
Cellular	(8)	7	5	5	7	7	6
Aggregates							
Cells	(8)	6	4	3	8	7	7
Organelles	(8)	3	5	4	4	6	6
Macromolecular	(8)	1	1	0	8	6	7
Aggregates							
Macromolecules	(8)	4	1	3	3	6	6
Molecules	(8)	2	1	4	6	5	8
Atoms	(8)	2	2	3	6	3	4
Viewpoint							
Energetics & Information	(20)	13	10	13	15	17	18
Techniques, Skills & Diversity	(20)	7	4	7	15	8	8
Time- & Process-related	(40)	20	15	23	27	33	33

B. Mean R Value where $R > 1$

Total	2.3	3.0	3.4	6.8	5.0	3.5
Level						
Populations & Larger Assocs.	1.3	1.0	4.3	2.0	3.0	2.3
Aggregates & Individuals	1.8	2.3	4.0	3.7	2.8	1.8
Individuals	3.6	4.7	3.7	3.3	7.6	3.6
Cellular	2.3	1.8	1.8	9.4	7.6	5.7
Aggregates						
Cells	2.8	4.0	3.3	11.9	8.0	4.9
Organelles	2.7	1.6	4.0	5.5	5.0	5.0
Macromolecular	2.0	1.0	0	5.5*	2.7	2.7
Aggregates						
Macromolecules	1.2	1.0	1.3	6.5	4.7	3.2
Molecules	1.0	2.0	2.0	13.7	3.6	1.9
Atoms	3.0	6.0	5.7	4.7	3.7	3.8
Viewpoint						
Energetics & Information	2.4	2.9	5.0	12.7*	7.0	5.2
Techniques, Skills & Diversity	3.6	6.5	4.3	7.1	3.4	2.4
Time- & Process-related	2.0	2.2	2.3	5.7	4.3	3.0

* Excluding intercept 25: $R = \infty$

range (between Organelles and Aggregates of Individuals). The single isolated common intercept, number 37, includes general and organic chemistry (Figure 2).

If the 19 common intercepts are related to the maximum possible number, as limited by the smallest number of prerequisites (29 for medical schools), there is an overall concordance of 68 percent (Table 6). Two out of every three biological areas considered desirable to prepare a student for studying human medicine are thus also desired by teachers of prospective nurses, pharmacists, etc. From Table 6 it is apparent that the concordance among any two kinds of schools is usually even higher. Similar tables can be drawn comparing responses for higher values of R. It is interesting to note that at $R > 1$ there is an 82 percent concordance among doctoral-level schools and an 81 percent agreement among baccalaureate-level schools, while at $R > 3$ the concordance for doctoral schools remains 83 percent and that of the others is only 65 percent. The overall concordance at $R > 3$ is again 67 percent.

Considering the questionnaire's "undesirable" intercepts ($R < 0$), representing areas best left to the professional schools, the agreements are as shown in the lower, italicized values in Table 6A. Doctoral-level schools show 50 percent concordance in their view of "undesirable" material

better postponed; baccalaureate schools have only 26 percent concordance. No intercepts were agreed to be "undesirable" by all school types.

V. Contrast between different groups within the dental and medical faculties.

The high concordances among dental and medical faculties, both in terms of desirable intercepts ($R > 1$) and undesirable ones ($R < 0$), suggested that the data from these two groups could be pooled. This larger sample was then analyzed in three different ways, as follows: separating the respondents by (a) the year of receipt of their doctoral degree, (b) the nature of their doctorates (professional or research degrees; combined degrees were included with the professional category), and (c) their role in clinical or basic teaching. Figure 13 shows those intercepts in which the combined medical and dental faculties agreed and disagreed on the information needed to prepare for professional education. The unshaded cells show uniform attribution of desirability ($R > 1$); darkly shaded cells had values of R uniformly less than 1. Light shading indicates cells in which some groups (identified by the letters assigned in the legend) produced a value of R greater than 1. There was agreement at 59 intercepts; of the remaining 21, ten showed disagreement by only one group, three by two

TABLE 6.
COMPARISONS BETWEEN SCHOOL TYPES

A. Possible Correspondence among Faculties (in percent)

	Dental	Medical	Vet. Med.	M. Tech.	Nursing	Pharmacy
Dental	(40*)	93**	80	88	88	97
Medical	(11*) 60***	(29)	86	86	90	100
Vet. Med.	33	83	(6)	67	81	83
M. Tech.	20	22	17	(13)	81	88
Nursing	56	67	33	11	(58)	91
Pharmacy	20	40	20	60	(9)	(59)

B. Relative Agreement on Prerequisite Intercepts

Dental	Medical	Vet. Med.	M. Tech.	Nursing	Pharmacy
<i>Nursing †</i>	<i>Vet. Med.</i>	<i>Medical</i>	<i>Pharmacy</i>	<i>Pharmacy</i>	<i>Nursing</i>
<i>Medical</i>	<i>Pharmacy</i>	<i>Dental</i>	<i>Medical</i>	<i>Medical</i>	<i>M. Tech.</i>
<i>Pharmacy</i>	<i>Dental</i>	<i>Nursing</i>	<i>Dental</i>	<i>Dental</i>	<i>Medical</i>
<i>Vet. Med.</i>	<i>Nursing</i>	<i>Pharmacy</i>	<i>Nursing</i>	<i>M. Tech.</i>	<i>Dental</i>
<i>M. Tech.</i>	<i>M. Tech.</i>	<i>M. Tech.</i>	<i>Vet. Med.</i>	<i>Vet. Med.</i>	<i>Vet. Med.</i>

†Italicized words show the groups with which there is substantial agreement.

*Represents the number of intercepts where R = 1 (roman font) and R = 0 (italic font) for each school type.

**Percent of possible common intercepts where R = 1 (roman font).

***Percent of possible common intercepts where R = 0 (italic font).

groups, seven by three groups, and one by four groups. Disagreement could be either positive ($R > 1$ for the dissenting groups and $R < 1$ for the general sample) or negative ($R < 1$ for the dissenters and $R > 1$ for the whole sample). Agreement was positive in 24 out of 38 cases and showed a separation by category. Positive deviation, indicating a desire for greater preparation, was largely associated with clinical faculties, professional degrees, and post-1950 doctorates. The lesser need for preparation expressed by the other groups was further shown by their preponderantly negative dissension (PhD holders were in negative disagree-

ment at four intercepts, basic-science faculty at three and pre-1950 degree holders at one). Recent degree recipients also showed negative disagreement at three intercepts, two of which occurred in conjunction with the PhD category. All but one of the positive deviations by recent degree recipients were associated with the MD category. The principal difference thus seems to be between holders of MD and PhD degrees and teachers in clinical and basic departments; in each case, the former prefer greater breadth of biological preparation.

In beginning to study the preprofessional educational requirements for the various health sciences, members of the Panel on Preprofessional Training for the Medical Sciences (PPTMS) were struck by two disturbing facts. First, there is an abiding unawareness of what is being taught in the courses presumed to be preparatory. Second, there is a similar uncertainty as to what constitutes preparation. We have viewed our function as primarily descriptive, i.e., identifying what constitutes necessary background material in the mind of professional school teachers. In reporting our results, we will attempt to describe current practices in the area of undergraduate biological education. This is done with knowledge that medical-science faculties are now or will soon begin moving towards curricular change in response to the same set of information that has stimulated change in secondary school and undergraduate curricula. The strength of this change appears in data collected by Littlemeyer (in press), Herron (in press) and CUEBS (1967). It is mirrored in the responses to our questionnaire, which showed more than half of the respondents to be in post-graduate institutions that already are planning modifications complementing new undergraduate programs. The apparent anomaly, that only one quarter expect these changes to result in revised admission requirements, probably means that the changes will be towards professional courses built on better preparation, possibly allowing faster completion of professional study. Medical specialties taught at the pre-doctoral level seem farther away from course revision. This may indicate a situation similar to that in colleges with biological science faculties of limited size where CUEBS has found curricular revision to proceed less rapidly than in schools with larger, research-oriented faculties.

Since post-graduate professional schools are not likely to change their present admission policies, even though their needs for biological preparation may become more stringent, undergraduate students must have access to needed information through formal courses, probably not exceeding one and one-half to two years duration. If students are to have an equal opportunity for professional study, all colleges must provide adequate coverage of preparatory material. This need is emphasized by the reliance often placed by admissions committees on uniform examinations. Future admissions committees will be even more strained to evaluate the technical background of prospective students as traditional course titles disappear from catalogs or become representative of different informational content. The CUEBS core-curriculum study (CUEBS, 1967) shows just a beginning of this new nomenclature. The Biological Information Grid (Figure 1B) itself is an attempt to escape from the constraints of traditional course labels (Figure 2). Adequate preparation for professional schools must include areas from more disciplines than can be covered in the traditional elementary biology course (phyletics, comparative anatomy and organ physiology).

Much the same conclusion has been reached in other discussions of this same subject (Grobstein, 1964; NAS-NRC, 1957; CUEBS, 1967; Roos, 1965).

There were wide variations in the responses obtained from faculty members of the different types of schools. This is dramatically shown by the differences in the index values at various grid intercepts (Figures 5-10 and Appendix C). Indeed, the faculties differed just in the matter of the number of intercepts desirable for preparation (Table 5A). The fewest requirements were stated by the medical schools and an intermediate number of needs were cited by the two other doctoral-level schools. Baccalaureate-level schools asked for the broadest preprofessional preparation. This apparent paradox of an inverse relation between the amount of prerequisite information and the duration of professional training probably reflects in part the amount of time given to practical, as contrasted to theoretical, study during the professional education. Thus, medical schools include relatively more preparatory material within the early stages of their curricula. Nursing and medical technology schools, with their greater emphasis on strictly professional skills, depend on greater undergraduate preparation for the theory upon which practice rests. Pharmacy remains anomalous, since much of pharmaceutical education occurs entirely under the aegis of pharmacy schools, although broad biological competence is demanded. Pharmacy faculties might well reconsider their relation to their university biology departments.

Comparing the needs of different types of schools for preparation at the various levels of biological organization, the doctoral-level schools form one group on the basis of their lesser need for preparation at molecular levels. This probably is related to the greater attention paid to biochemistry and molecular biology during professional study. The differences among doctoral-level schools at the Population and Aggregate of Individuals levels may relate to the increased emphasis, particularly in veterinary practice, on aspects of what might be termed environmental medicine (e.g., prophylaxis and community medicine). Recommendations for undergraduate psychology and sociology courses by some medical schools may also represent concern on their part for biological information at this level.

Baccalaureate-level schools are characterized by a broad, general background requirement in biology, with no emphasis at any particular level (Table 5A and B). Medical technology, as a laboratory-oriented specialty, showed relatively little concern with the higher biological levels. Nursing faculties expressed a somewhat stronger preference at the middle levels of organization (cell to individual).

Among the schools, distinctions based on viewpoint are in many ways the most interesting and reflect the greatest differences. No schools showed marked differences

in preference between the number of desirable intercepts in the Information-Energetics category (Table 5A), although medical faculties were alone in showing equal strength of response between the two components. All other faculties showed a two-to-one preference for Information over Energetics. The numbers of desirable intercepts for each school reflected the general variation between the school types. However, the intensity of response was quite different for medical and dental schools than for all of the other schools (Table 5B). This may indicate a relatively lesser need for descriptive biology in preparation for medical and dental school. Schools of medical technology were not included in this analysis, since one intercept (Energetics at the Macromolecular Aggregate level) was identified as "infinitely desirable" (no C or D responses).

The faculties of baccalaureate-level schools expressed more need for preparation in techniques and description than did faculties in the doctoral schools; this breadth was associated with relatively little enthusiasm, however, suggesting that its importance may be more cultural than real. Perhaps it reflects a lingering suspicion that human therapy requires an understanding of the biology of other organisms. Only the medical technology faculty noted a strong need for preprofessional education in biological techniques; the other faculties preferred preparation in biological diversity over skills by about five to one.

In the time-related aspects of the biological sciences, the differences between doctoral and baccalaureate-level schools became most apparent. The latter cited the importance of half again as many intercepts and with far greater internal agreement than the former (Table 5A and B). In some categories, the differences were immense, e.g., each of the baccalaureate schools asked for nine of the ten possible *Integration* intercepts; all of the doctoral schools combined asked for coverage of only five different ones (with eight positive responses). Doctoral schools also differed more among themselves, especially in the coverage desired in *Development* and *Integration*. In general, dental and veterinary faculties cited a need for greater preparation than did medical faculties. The reasons for this difference are obscure, but may again be related to the amount of time spent on theoretical material during professional education. It may also reflect the persistence of the apprenticeship tradition in medicine, as represented by internship and residency training.

Examining the responses for each type of school, the data may be summarized as follows:

1. *Schools of Dental Medicine.* There is a primary need for preparation in almost all aspects of organismal biology, with the greatest emphasis on Energetics and Information from Organelle to Population levels and on temporal aspects from Cell to Aggregate of Individuals levels. A secondary focus on biochemistry is chiefly directed towards the process of protein synthesis (but not to the chemistry of proteins) and to analytical procedures.

Dental school prerequisites were most like those of nursing, medical and pharmacy schools, with less similarity to the stated needs of veterinary and technology schools.

2. *Schools of Medicine.* The individual and his construction received primary emphasis. Areas identified as requisite for preparation were few in comparison with other types of schools and largely limited in scope. There was a greater concern for the desirability of, rather than necessity for, general understanding of biological principles. Greatest agreement was found in those intercepts that were most obviously classical. There was marked overlap between the stated requirements of medical schools and those of all others; the similarity was greatest to veterinary schools and least to schools of medical technology.

3. *Schools of Veterinary Medicine.* A general requirement was expressed for knowledge of individuals, groups of individuals and communities. There was a somewhat more selective need for preparation at cytological, organ and biochemical levels. These requirements were largely shared with the other doctoral-level (especially medical) schools. There was little common requirement with baccalaureate schools.

4. *Schools of Medical Technology.* These schools indicated the broadest general requirements for biological preparation from the individual level down. Except for some aspects of population biology, medical technologists would seem to need at least the "core" of a full undergraduate biology major, with particular emphasis on laboratory skills. Medical technology requirements were closest to those in pharmacy schools and, to a lesser extent, medical and dental schools.

5. *Schools of Nursing.* Broad, general preparation was indicated, with special emphasis on the organismic levels from Cell to Individual. Selected intercepts were identified as important at all levels, however. The only major category to escape demand was that of Techniques. There was relatively large emphasis put on population and community biology. Nursing shared many prerequisite requirements with schools of pharmacy and somewhat fewer with medical and dental schools. There was little concordance with either medical technology or veterinary medicine.

6. *Schools of Pharmacy.* These were similar in preparatory requirements to nursing schools, but with fewer demands at the population level. Where the needs differed from those of nursing schools, they resembled those of medical technology. There was moderate agreement with medical and dental schools.*

From the results of the analysis based on the time since the advanced degree was earned, the type of degree

*Recent changes recommended by the American Pharmaceutical Association in the curriculum for pharmaceutical education and prerequisites for admission to pharmacy schools stress the importance of the same areas identified in this study.

and the area of teaching interest, it appears that the demand for preparation is greater among teachers trained as health science professionals than among those trained for research. Thus a physician teaching a clinical course asks more preparatory breadth than a PhD teaching a basic course. By analogy, then, the high level of preparation asked by baccalaureate professional school faculties may be due to a high proportion of professionally oriented teachers. If this is true, baccalaureate medical science schools can afford to continue giving their own preparatory courses only if the breadth and depth of exposure approaches the level of a core program in biology (CUEBS 1967). The alternative, that the depth of required understanding is slight, makes the requirement absurd. It seems worthwhile for the faculties in question to spend some time reviewing their stated requirements and the use to which these requirements are put in professional education.

The material cited as prerequisite by medical faculties, supplemented to meet specific needs, might serve as a basis for all preprofessional training for medical science specialties. Most of this material is covered in present introductory courses (Grobstein, 1964; Roos, 1965; CUEBS, 1967). It should be emphasized that adequate preparation for professional school is not exclusive to one organizational level or viewpoint. In fact, the greater apparent need of dental schools would be satisfied by the same courses required of pre-medical students. Veterinary schools, however, seem to require so much more information at higher organizational levels that an extra course in ecology, behavior or environmental biology would be

useful. The three baccalaureate schools might best be served by asking their prospective students to take a full "core" program in biology (CUEBS, 1967) before or coincident with supplementary professional education. There seems no other way to provide the intellectual depth needed to support the biological breadth demanded. *It is important that whatever the stated requirements, the goal must be to provide preparation for continued professional education beyond the formal training period. Furthermore, this preparation must be provided as succinctly as possible.* For those students who will enter a post-baccalaureate program, this might be only two to four terms of biology. For those in a terminal baccalaureate-degree program, the amount of biological training should correspond to the "core" (i.e., generally required) material demanded of a student majoring in biology. This might amount to five or six courses. Professional schools contemplating a more practice-oriented curriculum may thus find that they require more, rather than less, preparation in biology.

Biology department faculties, on their part, must freely exercise their responsibility to reinterpret biology in the light of current understanding, presenting their subject as compactly as possible and avoiding undue proliferation of courses. It is unlikely that adequate future preparation for careers either in research or in the health specialties will be satisfied by traditional curricula. Neither can satisfactory understanding of mutual problems be achieved without a continuing discussion among all related faculties of the nature of requisite information and its most effective exposition.

SUMMARY AND RECOMMENDATIONS

1. Recent changes in understanding of biology have already produced new approaches to biological education in high schools and colleges and are beginning to influence curricula in professional schools in the health sciences. It is therefore necessary that continuous discussion be established and maintained within institutions and between professional groups to transmit news of course changes and requirements. Several specific mechanisms are suggested, including (a) standing university committees, composed of teachers of preprofessional and professional courses, to explore the contents and interdigitation of these courses; (b) improved catalog descriptions or supplements to catalog descriptions to provide admissions committees with more accurate and current information on the material taught in different courses and the sequence of its presentation; (c) regular symposia at meetings of societies in the health professions to inform members of these groups of new approaches both to undergraduate and professional school education; and (d) periodic reappraisal of professional school admission requirements and opportunities for advanced placement to take advantage of ongoing changes in undergraduate courses.

2. Preparation for practice in any of the health sciences must include a theoretical background in biology

equivalent to that in a biology core program. It is unimportant whether this background be obtained before or after entering professional school, but recognizing the breadth of information respondents deemed necessary, preparatory education may be more efficiently gained before, rather than concurrently with professional study. The orientation within these background areas should be towards gaining understanding rather than grades. Thus satisfactory performance in a rigorous course is preferable to superb performance in a trivial one. Special courses designed only to prepare students for professional study are inadequate.

3. Specific course requirements for preparation and admission to professional school should be kept to a minimum. This can be done by (a) keeping abreast of changes in undergraduate courses, (b) teaching all specific skills needed for practice at the professional school, rather than the preparatory level, and (c) redefining the aims of professional schools to fit the precise kinds of graduates they wish to produce. The last point requires that a student limit himself somewhat in his ultimate choice of schools, but this is done *de facto* at present; further definition of aims by each school within a profession could reduce student disillusionment and contribute to more effective education at all the various schools.

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FIGURE LEGEND

- Figure 1A. Instruction sections of the questionnaire distributed to schools in the health sciences to determine their specific needs for preparation in the biological sciences. The questionnaire included the biological information grid used as a device for organizing biological information.
- Figure 1B. The biological information grid in the format used to report the results of the questionnaire analysis in Figures 3 through 13.
- Figure 2. A schematic map of traditional subdisciplines of the biological and related sciences on the biological information grid.
- Figures 3 through 13. *Biological information deemed necessary to prepare students for professional studies in the health sciences. Unshaded squares show where prior information is considered desirable ($R \geq 1$ cf. the section entitled "Methods"). Diagonally shaded squares show areas of indifference toward preparation ($1 \geq R \geq 0$). Spotted squares show where information is considered undesirable for inclusion in pre-professional education ($R < 0$).*
- Figure 3. Total response based on individual answers of all respondents.
- Figure 4. Total response weighted to give equal value to the responses of all school types and to eliminate bias due to the greater numerical response of medical and dental schools.
- Figure 5. Response by members of dental school faculties.
- Figure 6. Response by members of medical school faculties.
- Figure 7. Response by members of veterinary school faculties.
- Figure 8. Response by members of medical technology school faculties.
- Figure 9. Response by members of nursing school faculties.
- Figure 10. Response by members of pharmacy school faculties.
- Figure 11. Comparison of responses by faculties of schools granting doctoral degrees (dental, medical, and veterinary medical schools). Diagonal shading represents agreement on R-values less than unity, vertical shading shows disagreement, with at least one type of school indicating the desirability of the specified information in pre-professional education. Unshaded and spotted squares show agreement among the three school types on R-values greater than one and less than zero, respectively.
- Figure 12. Comparison of responses by faculties of schools granting baccalaureate degrees (medical technology, nursing, and pharmacy). The shading code is as in Figure 11.
- Figure 13. Comparison of groups within the combined medical and dental school samples. The letters in the various squares show groups disagreeing with the R-value for the full sample, according to the following code: B, basic science faculty; C, clinical faculty; M, professional degree (MD, DDS, DMD, or other); N, doctorate granted before 1950; O, doctorate granted since 1950; P, research degree (PhD or other); joint research-professional degrees are included in group M). Code letters printed in roman type show values of $R < 1$ (sample value ≥ 1); code letters printed in italic type show values of $R \geq 1$ (sample value < 1). Unshaded squares indicate agreement among all groups on $R \geq 1$. Diagonal shading indicates agreement on $R < 1$.

**COMMISSION ON UNDERGRADUATE EDUCATION
IN THE BIOLOGICAL SCIENCES**

1717 Massachusetts Avenue, N.W., Washington, D.C. 20036

QUESTIONNAIRE ON PREPROFESSIONAL TRAINING FOR THE MEDICAL SCIENCES

Name _____ Title & Position _____

Institution _____ Degrees & Dates _____

Address _____

- 1) a) Please check the courses in biology that are recommended or required (or neither recommended nor required) by your school for professional training.

Area	Credit Hours	Required	Recommended	Neither Required nor Recommended
Physiology (Animal)				
Physiology (Cellular)				
Genetics				
Embryology				
Comparative Anatomy				
General Biology or Zoology				
Other Biology				

- b) What is the chief value of the required courses listed above to the Admissions Committee?

- ☐ a. Providing an index of prospective success in professional school?
☐ b. Providing an index of prospective success in practice?
☐ c. Providing assurance of adequate preparation for professional courses?
☐ d. Other: please specify

- c) How does your curriculum take advantage of the better preparation of students who have taken work beyond the minimum prerequisites for admission?

Figure 1A.

- 2) **RATIONALE**—We wish to determine precisely the kind of biological information needed for preprofessional training in the Medical Sciences. We have devised the following Biology Information Grids to identify specific areas of the biological sciences while yet not producing an unmanageably long questionnaire.

GRIDS—The grids on the following pages are designed to portray biology independently of its usual course titles. Ten levels of biological organization form the vertical vector of the grid, and two sets of four points of view form the horizontal vectors. The first grid incorporates descriptive or procedural phenomena. The second grid contains dynamic and sequential events.

Each cell within the array represents a given quality, process, observation, or procedure at a particular level of organization. Examples of specific biological studies are included within each cell. These examples are not meant to be inclusive, but only representative of material appropriate to that cell. Advanced courses will ordinarily consider material from only a few cells of the grid, but these will be examined in depth. Less advanced courses will cover more cells less thoroughly.

RATING SCALE—For each block in the grid, you are asked to mark the accompanying IBM answer sheet, according to the following rating system:

Mark Position A to indicate that the material is considered to be truly prerequisite and used in professional courses.

Mark Position B to indicate that the material would be highly desirable as background information, but not necessarily used or referred to in professional instruction.

Mark Position C to indicate material that in your judgment is best covered in detail during professional training, and hence its prior exposition is unnecessary.

Mark Position D to indicate that this material is not required and is irrelevant to professional training.

Mark Position E to indicate that the material in this block is covered in the course you teach. Position E may be marked regardless of the way in which A through D are marked.

For the purpose of scoring, we suggest that you consider material as "covered" if it is given the equivalent of at least one lecture or one lab, or 50 to 100 pages of reading. This may be considered to be the level of "minimal understanding."

- 3) Would you favor replacing existing course requirements by satisfactory performance on an achievement examination patterned after the Graduate Record Examination or the Science portion of the Medical College Achievement Test?

☐ yes

☐ no

- 4) Please comment on the general problem of preprofessional training, in your area, especially in regard to the biological sciences.

- 5) a) Is your school planning any extensive curricular revision in the near future that might take advantage of recent changes in undergraduate biology preparation?

☐ yes

☐ no

If yes, please describe the projected changes.

- b) Is your school planning any revised admission requirements?

☐ yes

☐ no

If yes, what changes are you planning?

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Pollution Biosphere	Systematic taxa Macroevolution	Mapping Field analysis Population statistics Meteorology Paleobiology Taxonomy	Ecosystems Taxa from genus through kingdom	Succession Macroevolution	Selection Breeding isolation	Societies	Migrations Population isolation and fragmentation Speciation
	1	2	3	4	41	42	43	44
AGGREGATES OF INDIVIDUALS	Food chains Ecosystems	Gene pool Population genetics Microevolution	Non-parametric statistics Ethology Observations of group behavior	Subgeneric taxa Breeding units Feeding units Plant and Animal Diversity	Nurture Learning (social evolution) Microevolution	Breeding Reproduction	Colonies Social behavior Castes Parasitism Mutualism	Population growth Social fragmentation Subspeciation
	5	6	7	8	45	46	47	48
INDIVIDUALS	Feeding activity Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Feeding with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis	Asexual reproduction
	9	10	11	12	49	50	51	52
CELLULAR AGGREGATES	Digestion Respiration	Memory Mass effects in differentiation Morphological geometry	Experimental embryology Organ culture Histological techniques Transplantation techniques	Comparative morphology of plants and animals	Morphogenesis Inductive interaction Organogenesis	Cell aggregation Organ regulation	Nervous systems Sensory Endocrine organs Circulation and translocation	Regeneration Fertilization
	13	14	15	16	53	54	55	56
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell recognition	Electrophysiological techniques Tissue culture Cytological techniques Photomicrography Cine-micrography	Cell types Comparative Cytology	Nuclear and cytoplasmic differentiation	Encystment Osmoregulation Phagocytosis Tactic and trophic responses	Neurons Sensory nerve endings Cytoplasmic currents	Mitosis Gametogenesis
	17	18	19	20	57	58	59	60
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polysome formation	Fine structure analysis Cell fractionation	Comparative fine structure	Organelle differentiation Variable structure	Absorption Excretion Secretion	Differential permeability of membranes Organelle distribution Nuclear-cytoplasmic segregation	Organelle replication: mitochondria, centrioles, plastids, and nucleus
	21	22	23	24	61	62	63	64
MACROMOLECULAR AGGREGATES	Enzymatic pathways	Enzyme-forming systems Quaternary structure	Polarization microscopy Sedimentation Polynucleotide chemistry	Membrane biochemistry Immunology Isosymes	Repression Inhibition Immunogenesis Sequence of genetic readout	Adaptive enzymes	Antigenicity Hormonal modulation of enzyme activity Polysomes	Chromosome replication Ribosomes Membranes Secondary fibers and cell walls
	25	26	27	28	65	66	67	68
MACROMOLECULES	Metabolic enzymes ATP synthesis Photosynthesis	Polynucleotides Polypeptides Tertiary structure	Protein analysis Electrophoresis Nucleotide analysis Enzyme kinetics Polysaccharide chemistry	Comparative protein and nucleic acid biochemistry Allosteric effects	Protein synthesis	Enzyme induction	Messenger RNA Transport RNA Ribosomes	Polynucleotide synthesis and replication Messenger RNA stability
	29	30	31	32	69	70	71	72
MOLECULES	Coenzymes Nucleotides	Primary and secondary structure Steroids, phospholipids, fats, amino acids, purines, pyrimidines, porphyrins	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative nutrition Vitamins Comparative excretion Analogues	Polymerization Molecular interconversions Nucleosynthesis	Photochemistry	Hormones Neurohumors	Depolymerization and cycling of storage products
	33	34	35	36	73	74	75	76
ATOMS	H ⁺ and ionisation Rarities Photoactivation P.O. ₂ C chemistry S chemistry	Ion flux Divalent metals Photoconductivity Membrane electrochemistry Thermodynamics	Ion absorption spectrometry IR and UV spectrometry Electrophysiology	Trace element nutrition Isotopes	Biogenesis Geochemistry	Selective absorption and reabsorption of ions	Phosphate coupling reactions	Conservation of essential trace elements
	37	38	39	40	77	78	79	80

Figure 1B

Behavior



Biochemistry and Molecular Biology



Chemistry



Developmental Biology



Ecology



Endocrinology



Evolution



Genetics



Histology and Cytology



Morphology and Morphogenesis



Physics



Physiology and Biophysics

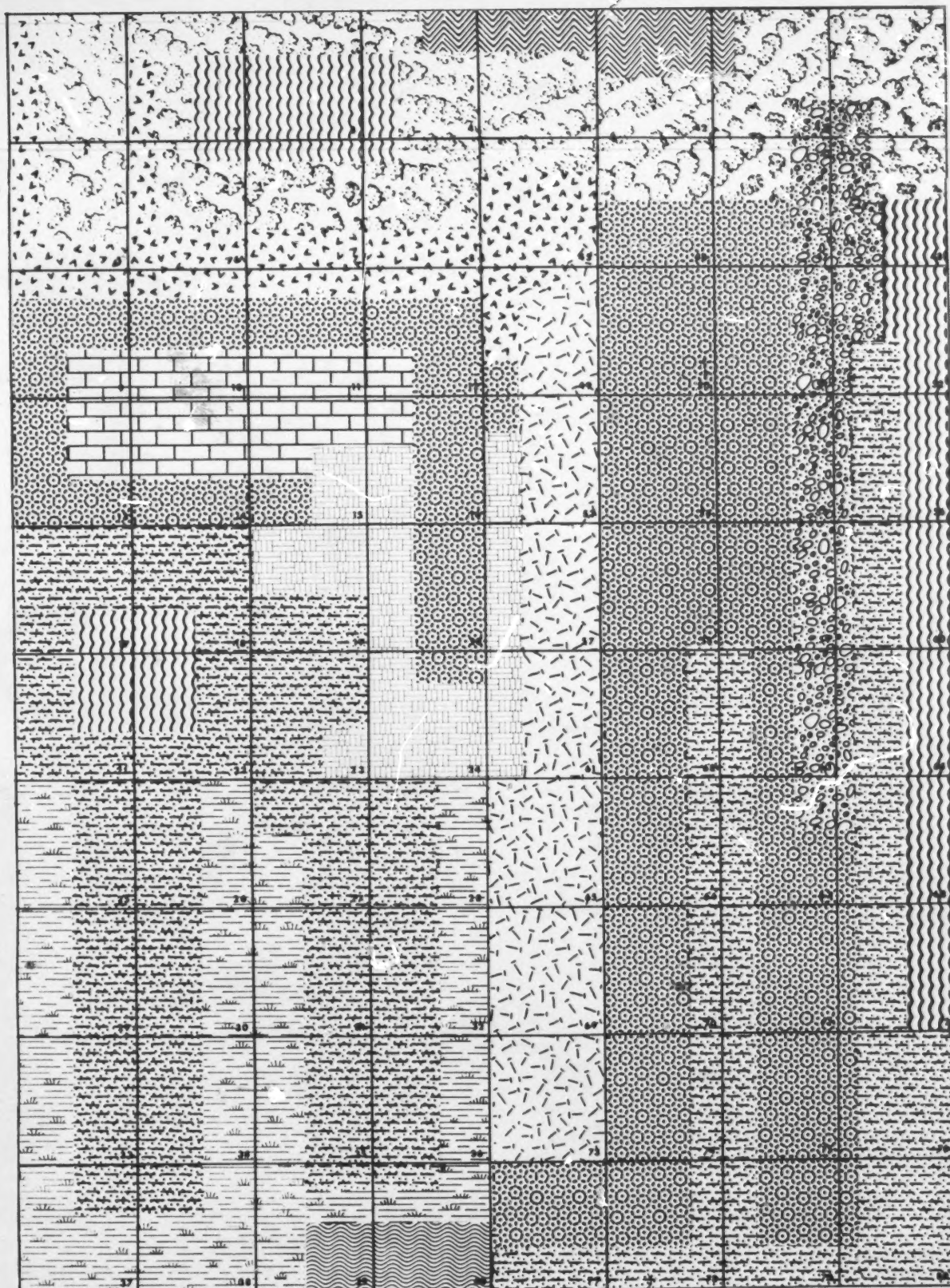


Figure 2.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Population dynamics	Systematic base Microevolution	Biological field analysis Population statistics Metapopulation Biogeography Taxonomy	Phylogenetic base Taxonomic diversity	Succession Macroevolution	Selection Breeding isolation	Societies	Allopatric Population isolation and speciation Reproduction
AGGREGATES OF INDIVIDUALS	Trade chains Ecophysiology	Gene pool Population genetics Microevolution	Non-parametric statistics Ecology Observations of group behavior	Phylogenetic base Breeding units Plant and Animal Diversity	History Taxonomic (social) Evolution Microevolution	Breeding Reproduction	Colonies Social behavior Castes Reproduction Metabolism	Population growth Ecological interactions Evolution
INDIVIDUALS	Feeding activity Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis	Animal reproduction
CELLULAR AGGREGATES	Digestion Respiration	Allopatry Mass effects in interspecific interactions Microevolution Secondary	Experimental embryology Organ culture Histological techniques Transplantation techniques	Comparative morphology of plants and animals	Morphogenesis Molecular interactions Ecophysiology Genome analysis	Cell aggregation Organ regulation	Nervous systems Sensory Endocrine organs Circulation and translocation	Regeneration Fertilization
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell recognition	Electrophysiological techniques Fluorimetry Cytological (cell culture) Microscopy Chemical synthesis	Cell types Comparative Cytology	Nuclear and cytoplasmic differentiation	Encystment Osmoregulation Phagocytosis Tactic and trophic responses	Neurons Sensory nerve endings Cytoplasmic currents	Mitosis Gametogenesis
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polyosome formation	Thin layer chromatography Cell fractionation	Comparative fine structure	Organelle differentiation Variable structure	Absorption Excretion Secretion	Differential permeability of membranes Organelle distribution Nuclear-cytoplasmic segregation	Organelle high-resolution mitochondria chloroplasts nucleus, and nucleus
MACROMOLECULAR AGGREGATES	Enzymatic pathways	Enzyme function Enzyme structure Quaternary structure	Polymerization Microscopy Sedimentation Polynucleotide chemistry	Membrane biochemistry Immunology Isozymes	Aggregation Inhibition Membrane permeability Sequence of genetic codes	Adaptive enzymes	Antigenicity Hormonal regulation of enzyme activity Polymerase	Chromosome replication Ribosomes Membranes Secondary fibers and cell walls
MACROMOLECULES	Metabolic enzymes ATP synthesis Photosynthesis	Polynucleotides Polysaccharides Tertiary structure	Protein analysis Electrophoresis Nucleotide analysis Enzyme kinetics Polysaccharide chemistry	Comparative protein and nucleic acid biochemistry Anticodon effects	Protein synthesis	Enzyme induction	Messenger RNA Transport RNA Ribosomes	Polynucleotide synthesis and replication Messenger RNA stability
MOLECULES	Overlapped molecules	Primary and secondary structure Steroids, phospholipids, fats, amino acids, purines, pyrimidines, porphyrins	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative nutrition Vitamins Comparative excretion Analogues	Polymerization Molecular ions Conjugated molecules	Photochemistry	Hormones Neurohumors	Depolymerization and cycling of stored products
ATOMS	H ⁺ and ionization Redox Photoexcitation PO ₄ ³⁻ C chemistry S chemistry	Ion flow Chemical bonds Photoconductivity Absorption spectra Spectroscopy Thermodynamics	Ion absorption spectroscopy IR and UV spectroscopy Thermogravimetry	Trace element nutrition Isotopes	Allopatric biochemistry	Selective absorption and reflection of light	Photochemical reactions	Production of essential trace elements

Figure 4.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Pollution Biosphere	Systematic taxa Macroevolution	Modeling Field analysis Population genetics Taxonomy Paleontology Taxonomy	Ecosystems Taxa from genus through kingdom	Adaptation Microevolution	Selection Breeding Evolution	Societies	Migration Population isolation Genetic drift Speciation
AGGREGATES OF INDIVIDUALS	Food chains Ecosystems	Gene pool Population genetics Microevolution	Non-parametric statistics Ecology Observations of social behavior	Biological communities Evolutionary relationships Plant and animal diversity	Nurture Learning (social evolution) Microevolution	Breeding Reproduction	Colonies Social behavior Castes Parasitism Mutualism	Population growth Social interactions Reproduction
INDIVIDUALS	Feeding activity Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis	Asexual reproduction
CELLULAR AGGREGATES	Digestion Respiration	Adaptation Inductive effects in differentiation Morphological plasticity	Experimental embryology Organ culture Histological techniques Transplantation techniques	Comparative morphology of plants and animals	Morphogenesis Inductive interaction Organogenesis	Cell aggregation Organ regulation	Nervous systems Sensory Endocrine organs Circulation and translocation	Regeneration Fertilisation
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell recognition	Electrophysiology Isotopes Tissue culture Cytological techniques Microscopy Chemical analysis	Cell types Comparative Cytology	Nuclear and cytoplasmic differentiation	Excystment Osmoregulation Phagocytosis Tactic and trophic responses	Neuronal Receptor nerve endings Cytoplasmic streaming	Mitosis Gametogenesis
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polyome formation	Fine structure analysis Cell fractionation	Comparative fine structure	Organelle differentiation Variable structure	Absorption Excretion Secretion	Cellular respiration Photosynthesis Oxidative phosphorylation Nuclear-cytoplasmic coordination	Organelle specialization Mitochondria Chloroplasts Centrioles Lysosomes
MACROMOLECULAR AGGREGATES	Enzymatic activity	Enzyme kinetics Enzyme purification	Polymerization Microscopy Electrophoresis Polymerization	Membrane biochemistry Immunology Isotopes	Regulation Inhibition Enzyme kinetics Structure of enzyme	Adaptive enzymes	Adaptation Enzyme induction Regulation of enzyme activity Phagocytosis	Chromosome replication Ribosomes Membranes Secondary fibers and cell walls
MACROMOLECULES	Metabolic enzymes ATP synthesis Photosynthesis	Polymers Polymers Tertiary structure	Protein analysis Electrophoresis Nucleic acid analysis Enzyme kinetics Polymerization	Comparative protein and nucleic acid biochemistry Allosteric effects	Protein synthesis	Enzyme induction	Messenger RNA Transport RNA Ribosomes	Polymerization Secondary structure Protein synthesis Stability
MOLECULES	Chemical reactions Proteins	Primary and secondary structure Enzymes, proteins Lipids, fats Amino acids Nucleic acids Carbohydrates	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative protein and nucleic acid biochemistry Allosteric effects	Polymerization Molecular interconversions Biosynthesis	Photochemicals	Proteins Nucleic acids	Depolymerization and cycling of stored products
ATOMS	H+ and ionisation Redox Photoexcitation PO4 C chemistry S chemistry	Ion flux Divalent metals Photosensitivity Membrane electrochemistry Thermodynamics	Ion absorption Spectrometry IR and UV spectrometry Electrophysiology	Trace elements Nutrition Isotopes	Regulation Biochemistry	Selective absorption and separation of ions	Photophosphorylation	Compression of essential trace elements

Figure 5.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Population dynamics	Systematic taxa Macroevolution	Modeling Field analysis Population statistics Meteorology Paleobiology Taxonomy	Ecophysiology Taxa and species Biological kingdom	Population Macroevolution	Selection Breeding isolation	Societies	Microevolution Population isolation and gene flow Speciation
AGGREGATES OF INDIVIDUALS	Food webs Microevolution	Gene pool Population genetics Microevolution	Sub-population Individuals Ecology Observations of group behavior	Subspecific taxa Breeding units Feeding units Plant and Animal Diversity	Natural selection (social evolution) Microevolution	Breeding Reproduction	Colonies Social behavior Castes Parasitism Mutualism	Population growth Social interactions Subpopulation
INDIVIDUALS	Feeding ecology Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis	Asexual reproduction
CELLULAR AGGREGATES	Digestion Respiration	Metabolism Mass effects in differentiation Morphological necessity	Experimental physiology Organ culture Histological techniques Dye techniques	Comparative morphology of plants and animals	Morphogenesis Inductive interaction Organogenesis	Cell aggregation Organ regulation	Nervous systems Sensory systems Behavioral patterns Orientation and translocation	Regeneration Fertilization
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell recognition	Electrophysiological techniques Tissue culture Cytological techniques Photomicrography Chemical microscopy	Cell types Comparative cytology	Nuclear and cytoplasmic differentiation	Encystment Osmoregulation Phagocytosis Tactic and trophic responses	Neural development Sensory systems Cytoskeletal patterns	Mitosis Gametogenesis
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polysome formation	Fluorescence analysis Cell fractionation Electron microscopy	Comparative fine structure	Organelle differentiation Variable structure	Absorption Excretion Secretion	Differential permeability of membranes Channel proteins Nuclear-cytoplasmic communication	Organelle replication mitochondria, plastids, and nucleus
MACROMOLECULAR AGGREGATES	Enzymatic activity	Enzyme function Enzyme structure Quaternary structure	Polarization microscopy Sedimentation Polynucleotide chemistry	Membrane biochemistry Immunology Enzymes	Reproduction Inhibition Immunological sequences of specific reactions	Adaptation Enzymes	Antigenicity Hormonal modulation of enzyme activity Polysaccharides	Chromosome replication Ribosomes Membranes Secondary fibers and cell walls
MACROMOLECULES	Metabolic enzymes ATP synthesis Photosynthesis	Polynucleotides Polypeptides Tertiary structure	Protein analysis Electrophoresis Nucleotide analysis Enzyme kinetics Polynucleotide chemistry	Comparative protein and nucleic acid biochemistry Allosteric effects	Protein synthesis	Enzyme induction	Enzyme regulation Enzyme inhibition Allosteric effects	Polynucleotide synthesis and regulation Membrane fluidity
MOLECULES	Enzymes Nucleotides	Primary and secondary structure Structure, function, and properties Hydrophobic, hydrophilic, and amphipathic Lipids, proteins, and nucleic acids	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative protein and nucleic acid biochemistry Allosteric effects	Protein synthesis	Enzyme induction	Enzyme regulation Enzyme inhibition Allosteric effects	Polynucleotide synthesis and regulation Membrane fluidity
ATOMS	H ⁺ and ionization Redox Photoionization PO ₄ ³⁻ C chemistry S chemistry	Ion flux Essential metals Membrane electrochemistry Thermodynamics	Electrophoresis X-ray diffraction Electrophoresis	Enzyme kinetics Enzyme inhibition Enzyme regulation	Protein synthesis	Enzyme induction	Enzyme regulation Enzyme inhibition Allosteric effects	Polynucleotide synthesis and regulation Membrane fluidity

Figure 6.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Pollution Biosphere	Systematic taxa Macroevolution	Mapping Field analysis Population statistics Microscopy Videotape Taxonomy	Ecosystems Taxa from genus through kingdom	Succession Macroevolution	Selection Breeding Isolation	Societies	Migrations Isolation Isolation and fragmentation Speciation
	1	2	3	4	41	42	43	44
AGGREGATES OF INDIVIDUALS	Food chains Ecosystems	Gene pool Populatic genetics Microevolution	Non-genetic statistics Modeling Observations at group level	Subgeneric Taxa Breeding units Feeding units Plant and Animal Diversity	Nurture Learning (social evolution) Microevolution	Breeding Reproduction	Colonies Social behavior Castes Parasitism Mutualism	Population growth Social fragmentation Subspeciation
	5	6	7	8	45	46	47	48
INDIVIDUALS	Feeding activity Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis	Asexual reproduction
	9	10	11	12	49	50	51	52
CELLULAR AGGREGATES	Digestion Respiration	Major ions effects in differentiation Morphological genetics	Electrophoretic techniques Organ culture Histological techniques Transplantation techniques	Comparative morphology of plants and animals	Morphogenesis Inductive interaction Organogenesis	Cell aggregation Organ regulation	Group behavior Ecological groups Dispersal and transformation	Regeneration Fertilisation
	13	14	15	16	53	54	55	56
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell elongation	Electrophysiological techniques Tissue culture Cytological techniques Photomicrography Cinematography	Cell types Comparative cytology	Nuclear and cytoplasmic differentiation	Development Cybernetics Phagocytosis Tactic and trophic responses	Neuron Sensory nerve endings Cytoplasmic supports	Mitosis Gametogenesis
	17	18	19	20	57	58	59	60
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polyome formation	Fine structure analysis Self fractionation	Comparative fine structure	Organelle differentiation Variable structure	Protein synthesis Fractionation	Differential permeability of membranes Channelled transport Nuclear-cytoplasmic relationships	Organelle replication: mitochondria, centriole, plastid, and nucleus
	21	22	23	24	61	62	63	64
MACROMOLECULAR AGGREGATES	Enzymatic pathways	Enzyme function Enzyme regulation Enzyme kinetics	Polarisation microscopy Sedimentation Polynucleotide chemistry	Membrane biochemistry Immunology Toxins	Regeneration Inhibition Immunogenesis Sequence of genetic material	Adaptive enzymes	Antigenicity Hormonal modulation of enzyme activity Polysomes	Chromosomal replication Protein synthesis Membrane synthesis Secondary structure and cell walls
	65	26	27	28	65	66	67	68
MACROMOLECULES	Proteins ATP synthesis Photosynthesis	Polynucleotides Polysaccharides Various substances	Enzyme analysis Chromatography Nucleic acid analysis Enzyme kinetics Polysaccharide chemistry	Comparative biochemistry Nucleic acid biochemistry Nucleic acid analysis	Protein synthesis	Enzyme induction	Messenger RNA Transport RNA Ribosomes	Polynucleotide synthesis Nucleic acid metabolism Nucleic acid analysis
	29	30	31	32	69	70	71	72
MOLECULES	Carbohydrates Nucleotides	Primary and secondary structure Steroids, phospholipids, fats, amino acids, purines, pyrimidines, porphyrins	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative nutrition Vitamins Comparative excretion Analogues	Polymerisation Molecular interconversions Biosynthesis	Photobiology	Hormonal modulation	Depolymerisation and cycling of storage products
	33	34	35	36	73	74	75	76
ATOMS	H+ and ionization Redox Photoexcitation PO4 C chemistry S chemistry	Ion flux Divalent metals Membrane electrochemistry Thermodynamics	Ion chromatography IR and UV spectroscopy Electrophoresis	Trace element nutrition Isotopes	Biogenesis Geochemistry	Electrical properties and measurement of ions	Phosphorylation reactions	Conservation of energy and matter
	37	38	39	40	77	78	79	80

Figure 7.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Pollution Biogeochemistry	Phylogenetic trees Macroevolution	Mapping Field analysis Population statistics Metecology Teleecology Taxonomy	Ecosystems Taxa from genus through kingdom	Succession Macroevolution	Selection Breeding isolation	Societies	Migrations Population isolation and fragmentation Speciation
AGGREGATES OF INDIVIDUALS	Food chains Ecosystems	Gene pool Population genetics Microevolution	Non-parametric statistics Ethology Observations of group behavior	Subspecies Taxa Breeding units Ecological units Plant and animal diversity	History Islands (archipelagos) Evolution Microevolution	Breeding Reproduction	Colonies Social behavior Castes Parasitism Mutualism	Population growth Social fragmentation Subspeciation
INDIVIDUALS	Feeding activity Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis	Asexual reproduction
CELLULAR AGGREGATES	Digestion Respiration	Memory Mass effects in differentiation Morphological 'glue' activity	Experimental embryology Organ culture Histological techniques Transplantation techniques	Comparative morphology of plants and animals	Morphogenesis Inductive interaction Organogenesis	Cell aggregation Organ regulation	Nervous systems Sensory Endocrine organs Circulation and translocation	Regeneration Fertilization
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell recognition	Electrophysiological techniques Tissue culture Cytological technique Photomicrography Cinematography	Cell types Comparative Cytology	Nuclear and cytoplasmic differentiation	Encystment Osmoregulation Phagocytosis Tactic and trophic responses	Neurons Sensory nerve endings Cytoplasmic currents	Mitosis Gametogenesis
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polyome formation	Electron microscopy Cell fractionation Cell wall structure	Comparative cell structure	Organelle differentiation Variable structure	Absorption Excretion Secretion	Differential permeability of membranes Organelle distribution Nuclear-cytoplasmic segregation	Organelle replication Mitochondria Plastids Nucleus
MACROMOLECULAR AGGREGATES	Enzymatic pathways	Enzyme-forming systems Quaternary structure	Polarization microscopy Sedimentation Polynucleotide chemistry	Membrane biochemistry Immunology Isosymes	Repression Inhibition Immunogenesis Sequence of genetic readout	Adaptive enzymes	Antigenicity Hormonal modulation of enzyme activity Polysomes	Chromosome replication Ribosomes Membranes Secondary fibers and cell walls
MACROMOLECULES	Metabolic enzymes ATP synthesis Photosynthesis	Polynucleotides Polypeptides Tertiary structure	Protein analysis Electrophoresis Nucleotide analysis Enzyme kinetics Polysaccharide chemistry	Comparative protein and nucleic acid biochemistry Allosteric effects	Protein synthesis	Enzyme induction	Messenger RNA Transport RNA Ribosomes	Polynucleotide synthesis and replication Messenger RNA stability
MOLECULES	Coenzymes Nucleotides	Primary and secondary structure Steroids, phospholipids, fats, amino acids, purines, pyrimidines, porphyrins	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative nutrition Vitamins Comparative excretion Analogues	Polymerization Molecular interconversions Biosynthesis	Photochemistry	Hormones Neurohumors	Dissolution and cycling of storage products
ATOMS	H ⁺ and ionisation Redox Photosensitivity PO ₄ ³⁻ C chemistry S chemistry	Ion flux Divalent metals Membrane electrochemistry Thermodynamics	Ion absorption spectroscopy IR and UV spectroscopy Electrophysiology	Trace element nutrition Isotopes	Proteins Carbohydrates	Selective absorption and reorption of ions	Phosphate coupling reactions	Conversion of spectral bands

Figure 8.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Pollution Biosphere	Systematics Macroevolution	Mapping Field analysis Population statistics Biology Paleontology Taxonomy	Ecosystems Taxa from genus through kingdom	Subgeneric Macroevolution	Speciation Speciating populations	Societies	Migrations Population isolation and fragmentation Speciation
AGGREGATES OF INDIVIDUALS	Food chains Ecosystems	Gene pool Population genetics Microevolution	Non-parametric statistics Ethology Observations of group behavior	Subgeneric Taxa Breeding units Feeding units Plant and Animal Diversity	Nurture Learning (social evolution) Microevolution	Breeding Reproduction	Colonies Social behavior Castes Parasitism Mutualism	Population growth Social fragmentation Subspeciation
INDIVIDUALS	Feeding activity Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis	Asexual reproduction
CELLULAR AGGREGATES	Digestion Respiration	Memory Mass effects in differentiation Morphological geometry	Comparative morphology Organ culture Micrological techniques Transplantation techniques	Comparative morphology of plants and animals	Morphogenesis Inductive interaction Organogenesis	Cell aggregation Organ regulation	Nervous systems Sensory Endocrine organs Circulation and translocation	Regeneration Fertilization
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell recognition	Electrophysiological techniques Tissue culture Cytological techniques Photomicrography Cinematography	Cell types Comparative Cytology	Nuclear and cytoplasmic differentiation	Encystment Osmoregulation Phagocytosis Tactic and trophic responses	Neurons Sensory nerve endings Cytoplasmic currents	Mitosis Gametogenesis
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polyome formation	Fine structure analysis Cell fractionation	Comparative fine structure	Organelle differentiation Variable structure	Absorption Excretion Secretion	Differential permeability of membranes Organelle distribution Nuclear-cytoplasmic segregation	Organelle replication: mitochondria, centrioles, plastid, and nucleus
MACROMOLECULAR AGGREGATES	Enzymatic pathways	Enzyme-forming systems Quaternary structure	Polymerization Microscopy Sedimentation Polynucleotide chemistry	Membrane biochemistry Immunology Isozymes	Repression Inhibition Immunogenesis Sequence of genetic readout	Adaptive enzymes	Membrane permeability Regulation of enzyme activity Polymerization	Chromosome replication Ribosomes Membranes Secondary fibers and cell walls
MACROMOLECULES	Metabolic enzymes ATP synthesis Photosynthesis	Polynucleotides Polypeptides Tertiary structure	Protein analysis Monomer analysis Polymer analysis Enzyme kinetics Polymerization chemistry	Comparative protein and nucleic acid biochemistry Allosteric effects	Protein synthesis	Enzyme induction	Messenger RNA Transport RNA Ribosomes	Polynucleotide synthesis and replication Messenger RNA stability
MOLECULES	Coenzymes Nucleotides	Primary and secondary structure Steroids, phospholipids, fats, amino acids, purines, pyrimidines, porphyrins	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative nutrition Vitamins Comparative secretion Analogues	Polysaccharide synthesis, degradation, and metabolism	Photosynthesis	Hormones Neurohumors	Depolymerization and cycling of storage products
ATOMS	H ⁺ and ionization Radon Photoionization PO ₄ ³⁻ C chemistry S chemistry	Non-linear Molecular orbital Molecular orbital Molecular orbital Molecular orbital	Ion chromatography Spectrometry IR and UV spectroscopy Electrophysiology	Trace element Isotopes	Protein synthesis Chemistry	Selective absorption and reabsorption of ions	Phosphate coupling reactions	Comparison of molecular structures

Figure 9.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Pollution Biosphere	Systematic taxa Macroevolution	Mapping Field analysis Population statistics Mentology Phlebotomy Taxonomy	Ecosystems Taxa from genus through kingdom	Evolution Macroevolution	Selection Breeding Reproduction	Selection Breeding Reproduction	Migrations Population isolation and fragmentation Speciation
AGGREGATES OF INDIVIDUALS	Food chains Ecosystems	Gene pool Population genetics Microevolution	Non-parametric statistics Ethology Observations of group behavior	Subgenetic taxa Breeding units Plant and Animal Diversity	Nature Learning (social evolution) Microevolution	Breeding Reproduction	Colonies Social behavior Caste Parasitism Mutualism	Population growth Social organization Subpopulation
INDIVIDUALS	Feeding activity Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis	Asexual reproduction
CELLULAR AGGREGATES	Digestion Respiration	Memory Marked effects in differentiation Morphological symmetry	Experimental embryology Organ culture Histological techniques Transplantation techniques	Comparative morphology of plants and animals	Morphogenesis Inductive interaction Organogenesis	Cell aggregation Organ regulation	Nervous systems Sensory Endocrine organs Circulation and translocation	Regeneration Fertilization
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell recognition	Electrophysiological techniques Tissue culture Cytological techniques Photomicrography Cinematography	Cell types Comparative Cytology	Nuclear and cytoplasmic differentiation	Encystation Osmoregulation Phagocytosis Tactic and trophic responses	Neuron Sensory nerve endings Cytoplasmic currents	Mitosis Gametogenesis
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polysome formation	Five electron analysis Cell fractionation	Comparative fine structure	Organelle differentiation Variable structure	Absorption Excretion Secretion	Differential permeability of membranes Organelle distribution Nuclear-cytoplasmic segregation	Organelle replication: mitochondria, centriole, plastid, and nucleus
MACROMOLECULAR AGGREGATES	Enzymatic pathways	Enzyme-forming systems Quaternary structure	Polymerization Microscopy Electrophoresis Polynucleotide chemistry	Membrane biochemistry Immunology Isosymes	Repression Inhibition Immunogenesis Sequence of genetic readout	Adaptive enzymes	Antigenicity Hormonal modulation of enzyme activity Polysomes	Chromosome replication Ribosomes Membranes Secondary fibers and cell walls
MACROMOLECULES	Metabolic enzymes ATP synthesis Photosynthesis	Polynucleotides Polypeptides Tertiary structure	Protein analysis Microscopy Electrophoresis Enzyme kinetics Polynucleotide chemistry	Comparative function and structure Enzyme kinetics Allosteric effects	Protein synthesis	Enzyme induction	Messenger RNA Transport RNA Ribosomes	Polynucleotide synthesis and replication Messenger RNA stability
MOLECULES	Coenzymes Nucleotides	Primary and secondary structure Steroids, phospholipids, fats, amino acids, purines, pyrimidines, porphyrins	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative nutrition Vitamins Comparative excretion Analogues	Polymerization Molecular interconversions Biosynthesis	Photochemistry	Hormones Neurohumors	Depolymerization and cycling of storage products
ATOMS	H ⁺ and ionization Acid Photoexcitation PO ₄ ³⁻ C chemistry S chemistry	Ion flux Valent metals Photoexcitation Membrane electrochemistry Thermodynamics	Ion absorption Spectroscopy X-ray fluorescence Electrochemistry	Ion absorption Spectroscopy X-ray fluorescence Electrochemistry	Ion absorption Spectroscopy X-ray fluorescence Electrochemistry	Selective absorption and reabsorption of ions	Phosphate coupling reactions	Conservation of energy in systems

Figure 10.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Photosynthesis Respiration	Systematic taxa Macroevolution	Comparative Phylogenetic Taxonomy Population Genetics Mendelian Genetics Taxonomy	Systematic Taxa (from species through kingdoms)	Supra-species Macroevolution	Selection Breeding Evolution	Societies	Selection Population Genetics Speciation
AGGREGATES OF INDIVIDUALS	Food chains Ecosystems	Gene pool Population genetics Microevolution	Non-genetic Taxonomy Ecology Observations of group behavior	Sub-specific taxa Phylogenetic units Phylogenetic units Phylogenetic units	Phylogenetic units Phylogenetic units Phylogenetic units	Breeding Reproduction	Colonies Social behavior Castes Parasitism Mutualism	Population Genetics Social Evolution Subspeciation
INDIVIDUALS	Feeding activities Feeding relationships Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual vari- ability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cytoplasmic Membranes	Asexual repro- duction
CELLULAR AGGREGATES	Digestion Respiration	Metabolic effects in differentiated morphological systems	Experimentation Observations Organ culture Histology Transplantation Techniques	Comparative mor- phology of plants and animals	Morphogenesis Inductive inter- action Organogenesis	Cell aggregation Organ regulation	Myofibrils Nuclei Cytoplasmic organelles Circulation and translocation	Regeneration Fertilization
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell morphology	Electrophysiological techniques Tissue culture Cytological tech- niques Microphysiology Observations	Cell type differentiation Cytology	Nuclear and cyto- plasmic differen- tiation	Cell division Differentiation Phenotypic factors and genetic responses	Neurons Secretory cells Endothelial cells Epithelial cells	Mitosis Germogenesis
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polysome formation	Thin structural analysis Cell fractiona- tion	Comparative fine structure	Organelle differentiation Variable structure	Alteration Lysosomes Vacuoles	Differential permeability of membranes Organelle destruc- tion Nucleus, cytoplasm, etc. responses	Organelle func- tion Mitochondria Plastids, and nucleus
MACROMOLECULAR AGGREGATES	Enzymatic activ- ity	Enzyme function Enzyme structure	Polymerization microscopy Electrophoresis Polymerization Chemistry	Membrane bio- chemistry Immunology Isotopes	Regulation Initiation Termination Secondary structure of genetic material	Adaptive enzymes	Analogous Nonenzymatic or enzyme action Polymers	Chromosomal rearrange- ments Secondary (fibrils and cell walls)
MACROMOLECULES	Mitochondrial ATP synthase Thymine kinase	Polysaccharides Polymers Protein structure	Protein analysis Electrophoresis Polymerization Chemistry	Comparative pro- tein and nucleic acid chemistry Allosteric effects	Protein synthesis	Enzyme function	Mitochondrial ATP synthase Thymine kinase	Polysaccharide structure and function Protein structure and function
MOLECULES	Disaccharides Polysaccharides	Primary and secondary structure Structure, function, location, fate, metabolic pathways, etc.	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative analysis Chemical analysis Protein analysis	Polymerization Analysis Structure Function	Protein synthesis	Protein structure Function	Depolymerization and cycling of storage products
ATOMS	H ⁺ and ionization Radio Photoexcitation PO ₄ ³⁻ C chemistry S chemistry	Ion flux Divalent metals Membrane electro- chemistry Thermodynamics	Electrophoresis Microscopy Infrared spectroscopy Fluorescence	Thin structural analysis Protein analysis	Protein synthesis	Enzyme function	Protein structure Function	Depolymerization and cycling of storage products

Figure 11.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Photosynthesis Respiration	Symbiotic and Microcosms	Mapping Field analysis Population Statistics Histology Physiology Taxonomy	Ecosystems Taxa from genus through kingdom	Biogeography Macroeconomics	Selection Speciation Isolation	Societies	Migration Population isolation and inter- population interaction
AGGREGATES OF INDIVIDUALS	Food chains Endosymbiosis	Gene pool Population genetics Microevolution	Non-symbiotic symbiosis Evolution Observations of group behavior	Autogenic and allochthonous Food webs Plant and animal diversity	Human Evolution Evolution Microevolution	Breeding Reproduction	Colonies Social behavior Castes Parasitism Mutualism	Population growth Social organization Subsistence
INDIVIDUALS	Feeding activity Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis	Asexual repro- duction
CELLULAR AGGREGATES	Digestion Respiration	Memory Mass effects Differentiation Microbiological properties	Experimental analysis Group culture Microscopic tech- niques Physiological techniques	Comparative mor- phology of plants and animals	Morphogenesis Inductive inter- action Organogenesis	Cell aggregation Organ regulation	Nervous systems Sensory Endocrine organs Circulation and translocation	Regeneration Fertilization
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell recognition	Electrophysiological techniques Tissue culture Cytoplasmic tech- niques Pharmacological physiology	Cell types Comparative Cytology	Nuclear and cyto- plasmic differen- tiation	Encystment Osmoregulation Phagocytosis Tactic and trophic responses	Neurons Sensory nerve endings Cytoplasmic currents	Mitosis Gametogenesis
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polysome formation	Thin structure analysis Cell fractiona- tion	Comparative fine structure	Organelle differentiation Variable morphology	Absorption Excretion Secretion	Differential permeability of membranes Organelle distri- bution Nuclear-cytoplas- mic segregation	Organelle repro- duction Autophagy Centrioles Plastids and nucleoli
MACROMOLECULAR AGGREGATES	Enzymatic path- ways	Enzyme-forming systems Quaternary structure	Polarization Microscopy Sedimentation Polynucleotide chemistry	Membrane bio- chemistry Immunology Isozymes	Regression Inhibition Immunogenesis Sequence of genetic readout	Adaptive enzymes	Allosteric Modulation of enzyme activity Polysomes	Chromosome repli- cation Ribosomes Membranes Secondary fibers and cell walls
MACROMOLECULES	Metabolic enzymes ATP synthesis Photosynthesis	Polynucleotides Polypeptides Tertiary structure	Protein analysis Electrophoresis Nucleotide analysis Enzyme kinetics Polynucleotide chemistry	Comparative pro- tein and nucleic acid biochemistry Allosteric effects	Protein synthesis	Enzyme induction	Messenger RNA Transport RNA Ribosomes	Polynucleotide syn- thesis and repli- cation Messenger RNA stability
MOLECULES	Coenzymes Nucleotides	Primary and secondary structure Steroids, phospho- lipids, fats, amino acids, purines, pyrimi- dines, porphyrins	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Liquid chromatography	Comparative nutrition Vitamins Comparative nutrition Analysis	Polymerization Molecular inter- actions Biophysics	Photobiology	Hormones Neurohumors	Regeneration and cycling of storage products
ATOMS	H ⁺ and ionization Radio Photoionization PO ₄ ³⁻ C chemistry S chemistry	Ion flux Ion channel activity Radioisotopes Electro- chemistry Spectrophysics	Ion absorption spectroscopy Ion and UV spectroscopy Electrochemistry	Trace element nutrition Isotopes	Biogeochemistry	Selective absorption and reorption of ions	Phosphate coupling reactions	Coordination of catalytic and storage functions

Figure 12.

	ENERGETICS	INFORMATION	METHODS & SKILLS	STRUCTURAL DIVERSITY	DEVELOPMENT	ADAPTATION	INTEGRATION	PROLIFERATION
POPULATIONS & LARGER ASSOCIATIONS	Energy cycles Pollution Biosphere NCMP	Systematic taxa Macroevolution N	Isolating Taxa polymorphs Phylogenies Morphologies Paleobiology Taxonomy	Ecosystems Taxa from genus through kingdom M	Recreation Macroevolution CM	Adaptation Speciation Isolation	Societies NCM	Microevolution Population, speciation and macroevolution
AGGREGATES OF INDIVIDUALS	Taxa chains Ecogenesis	Gene pool Population genetics Microevolution	Non-synthetic polymorphs Ecology Observations of group behavior	Subspecies from breeding units Ecology Phylogenies and Macroevolution	Marking Learning (social evolution) Macroevolution NCM	Breeding Reproduction	Colonies Social behavior Castes Parasitism Mutualism OP	Population growth Social transformation Subspeciation
INDIVIDUALS	Feeding activity Feeding preferences Choice of habitat	Sensory mechanisms Rhythmic behavior Memory Polymorphism	Dissection Facility with a taxonomic key Observations of individual behavior	Individual variability Comparative physiology Mendelian genetics Comparative embryology	Growth Aging Maturation Developmental Genetics	Behavior	Cybernetics Homeostasis C	Asexual reproduction
CELLULAR AGGREGATES	Digestion Respiration	Adaptation Macromolecules Differentiation Morphological secondary	Experimental embryology Organ culture Histological techniques Differentiation techniques	Comparative morphology of plants and animals	Morphogenesis Inductive interaction Organogenesis	Cell aggregation Organ regulation	Nervous systems Sensory Endocrine organs Circulation and translocation B	Regeneration Fertilization
CELLS	Absorption Excretion Membrane transport Phagocytosis	Cell recognition NBP	Electrophysiological techniques Tissue culture Physiological techniques Pharmacology Cytology	Cell types Comparative Cytology P	Nuclear and cytoplasmic differentiation	Encystment Osmoregulation Phagocytosis Tactic and trophic responses C	Adaptation Sensory nerve endings Cytoplasmic streaming	Mitosis Gametogenesis
ORGANELLES	Mitochondria Plastids	Chromosomes Self-replicating units Polyome formation	Pipe structure analysis Cell differentiation	Comparative life cycles	Organelle differentiation Visible structure MBM	Absorption Excretion Secretion	Differentiation Sensitivity of membranes Organelle distribution Water-enzyme-ATC interaction	Organelle replication: mitochondria, plastids, and nucleus NCM
MACROMOLECULAR AGGREGATES	Enzymatic pathways	Enzyme-enzyme systems Quaternary structure	Polymerization Microscopy Biogenesis Polymerization chemistry	Macromolecular chemistry Macromolecular structure	Regulation Inhibition Immunochemistry Synthesis of genetic material	Adaptive enzymes	Adaptation Regulation of enzyme activity Polymers	Chromosome replication Ribosomes Membranes Secondary fibers and cell walls
MACROMOLECULES	Metabolic enzymes ATP synthesis Photosynthesis	Polymerization Polymerization Tertiary structure	Protein analysis Electrophoresis Nucleic acids Protein structure Polymerization chemistry	Comparative protein and nucleic acid chemistry Allosteric effects	Protein synthesis	Enzyme induction	Membrane RNA transport RNA ribosomes	Polymerization synthesis and replication Membrane RNA transfer
MOLECULES	Enzymes Nucleotides	Primary and secondary structure Steroids, phospholipids, etc. Enzymes, proteins, etc. Polymerization	Chromatography Quantitative analysis Qualitative analysis Spectrophotometry Lipid chemistry	Comparative protein and nucleic acid chemistry Polymerization Polymerization Polymerization	Polymerization Macromolecular structure Macromolecular structure	Microchemistry	Enzymes Nucleotides	Enzymes Nucleotides Polymerization
ATOMS	H ⁺ and ionization Redox Photoexcitation PO ₄ ³⁻ C chemistry S chemistry	Ion flux Divalent metals Membrane electrochemistry Thermodynamics	Ion flux Spectrophotometry IR and UV spectroscopy Electrophysiology	Ion flux Spectrophotometry IR and UV spectroscopy Electrophysiology	Ion flux Spectrophotometry IR and UV spectroscopy Electrophysiology	Ion flux Spectrophotometry IR and UV spectroscopy Electrophysiology	Ion flux Spectrophotometry IR and UV spectroscopy Electrophysiology	Ion flux Spectrophotometry IR and UV spectroscopy Electrophysiology

Figure 13.

Roman initial, negative disagreement; Italic initial, positive agreement

RESPONDENT MEDICAL SCHOOLS

United States

Albany Medical School, New York
 *Albert Einstein College of Medicine
 Baylor University College of Medicine
 Bowman-Gray School of Medicine
 *California College of Medicine
 (Now Univ. of Calif., Irvine.)
 Case Western Reserve University School of Medicine
 *Chicago Medical School
 College of Physicians and Surgeons, Columbia University
 *Cornell University Medical College
 Duke University School of Medicine
 *Georgetown University School of Medicine
 George Washington University School of Medicine
 Indiana University School of Medicine
 Jefferson Medical College of Philadelphia
 Johns Hopkins University School of Medicine
 Louisiana State University School of Medicine
 Loma Linda University School of Medicine
 Marquette University School of Medicine
 *Medical College of Alabama
 Medical College of Georgia
 Medical College of Virginia
 New Jersey College of Medicine and Dentistry
 New York University School of Medicine
 *Northwestern University Medical School
 Ohio State University College of Medicine
 *Rutgers Medical School
 State University of New York
 Downstate Medical Center
 Buffalo Medical Center
 Stanford University School of Medicine
 Stritch School of Medicine of Loyola University
 Temple University School of Medicine
 Tufts University School of Medicine
 University of Arkansas Medical School
 University of California School of Medicine, Los Angeles
 University of Chicago School of Medicine
 University of Cincinnati College of Medicine
 *University of Colorado School of Medicine
 University of Florida College of Medicine
 University of Illinois College of Medicine
 University of Kansas School of Medicine
 University of Kentucky College of Medicine
 *University of Louisville School of Medicine
 University of Maryland School of Medicine
 University of Miami School of Medicine
 University of Michigan Medical School
 University of Minnesota Medical School

*Indicates only single respondent

University of Mississippi School of Medicine
 University of Missouri School of Medicine
 University of New Mexico School of Medicine
 *University of North Carolina School of Medicine
 University of Oklahoma School of Medicine
 University of Pennsylvania School of Medicine
 University of Pittsburgh School of Medicine
 University of Rochester School of Medicine
 University of South Dakota School of Medicine
 University of Southern California School of Medicine
 University of Tennessee College of Medicine
 University of Texas
 Southwestern Medical School, Dallas
 Medical Branch, Galveston
 *University of Utah College of Medicine
 University of Virginia School of Medicine
 University of Wisconsin Medical School
 *Wayne State School of Medicine, Michigan
 Washington University School of Medicine, Missouri

Canadian and Foreign

American University of Beirut Medical School, Lebanon
 Dalhousie University Faculty of Medicine
 Queens University Faculty of Medicine
 University of Alberta Faculty of Medicine
 *University of Saskatchewan College of Medicine
 *University of Manitoba Faculty of Medicine

RESPONDENT NURSING SCHOOLS

Arizona State University
 Ball State University
 California State College at Long Beach
 Catherine Spalding College, Kentucky
 Cornell University
 Creighton University
 Duke University, North Carolina
 Florida State University
 Incarnate Word College, Texas
 Louisiana State University
 Marillac College, Missouri
 Montana State University
 Mount St. Mary's College, Los Angeles
 New York University
 Northeast Louisiana State College
 Northern Illinois University
 Russell Sage College, New York
 St. Olaf College
 Simmons College
 Tuskegee Institute
 University of California, San Francisco
 University of Maryland
 University of Miami, Florida

University of Michigan
 University of Mississippi
 University of Nevada
 University of Pittsburgh
 University of Rochester
 University of Southwestern Louisiana
 University of Washington
 Villa Maria College, Pennsylvania

RESPONDENT DENTAL SCHOOLS

United States

Baylor University College of Dentistry
 *Case Western Reserve University School of Dentistry
 *Columbia University School of Dental and Oral Surgery
 *Creighton University School of Dentistry
 *Emory University School of Dentistry
 Fairleigh Dickinson School of Dentistry
 *Harvard School of Dental Medicine
 Howard University College of Dentistry
 *Indiana University School of Dentistry
 Loma Linda University School of Dentistry
 Loyola University School of Dentistry, Chicago
 Loyola University School of Dentistry, New Orleans
 Maharry Medical College, School of Dentistry
 *Marquette University School of Dentistry
 New York University College of Dentistry
 Northwestern University School of Dentistry
 *St. Louis University School of Dentistry
 State University of New York School of Dentistry, Buffalo
 Temple University School of Dentistry
 *Tufts University School of Dental Medicine
 University of Alabama School of Dentistry
 University of California School of Dentistry
 *Los Angeles
 San Francisco
 University of Detroit School of Dentistry
 *University of Iowa College of Dentistry
 University of Kentucky College of Dentistry
 University of Maryland School of Dentistry
 *University of Michigan School of Dentistry
 University of Minnesota School of Dentistry
 University of Missouri School of Dentistry
 *University of Nebraska College of Dentistry
 *University of North Carolina School of Dentistry
 University of Oregon Dental School
 *University of Pacific School of Dentistry
 University of Pennsylvania School of Dental Medicine
 University of Pittsburgh School of Dentistry
 University of Puerto Rico School of Dentistry
 University of Southern California School of Dentistry
 University of Tennessee College of Dentistry
 University of Texas Dental Branch
 Washington University School of Dentistry, Missouri

*only single respondent

Canada

*University of Alberta Faculty of Dentistry
 *University of Manitoba Faculty of Dentistry
 University of Montreal Dental Faculty

RESPONDENT PHARMACY SCHOOLS

Auburn University
 Butler University
 Columbia University
 Creighton University
 Massachusetts College of Pharmacy
 Medical College of Virginia
 Mercer University, Georgia
 Northeastern University
 Northeast Louisiana State College
 Ohio State University
 Philadelphia College of Pharmacy and Science
 Purdue University
 Rutgers University
 St. John's University
 St. Louis College of Pharmacy
 Stanford University
 South Dakota State University
 Southwestern State College, Oklahoma
 State University of New York, Buffalo
 Temple University
 Texas Southern University
 University of Arizona
 University of Arkansas
 University of California, San Francisco
 University of Colorado
 University of Connecticut
 University of Florida
 University of Houston
 University of Illinois
 University of Iowa
 University of Kansas
 University of Kentucky
 University of Minnesota
 University of Missouri, Kansas City
 University of Montana
 University of Nebraska
 University of New Mexico
 University of North Carolina
 University of Oklahoma
 University of Southern California
 University of Tennessee
 University of Toledo
 University of Utah
 University of Washington
 University of West Virginia
 University of Wisconsin
 University of Wyoming
 Washington State University
 Wayne State University

RESPONDENT MEDICAL TECHNOLOGY SCHOOLS

Anderson College
Aurora College
Ball State Teachers College
Beaver College
Bridgeport University
Butler University
Colby Junior College
Concord College
DePauw University
East Central State College
Fairleigh Dickinson University
Florida State University
Franklin College
Georgia State College for Women
Lewis and Clark College
Macalester College
Marywood College
Michigan State University
Morehead State College
Northeastern University
North Dakota State University
Northwestern University
Oglethorpe University
Oklahoma Baptist University
Oklahoma College for Women
Oklahoma State University
Purdue University
St. Louis University
Seattle University
Southwestern State College
State University of New York, Buffalo
Temple University
University of California, San Francisco
University of Georgia
University of Hawaii
University of Louisville
University of Michigan
University of Minnesota

University of Nebraska
University of North Dakota
University of Oklahoma
University of Pennsylvania
University of Southern Mississippi
University of Tennessee
University of Vermont
University of Wisconsin, Madison
University of Wisconsin, Milwaukee
William Carey College

RESPONDENT HOSPITAL-AFFILIATED MEDICAL TECHNOLOGY SCHOOLS

Cedars of Lebanon — Mt. Sinai Medical Center, Los Angeles
**Florida State Hospital, Chattahoochee
Moses H. Cone Memorial Hospital, Greensboro, North Carolina
**Phoebe Putney Hospital, Albany, Georgia
St. Jude Hospital, Fullerton, California

RESPONDENT VETERINARY SCHOOLS

Auburn University
Colorado State University
Iowa State University
Ohio State University
Oklahoma State University
Purdue University
Texas A & M University
Tuskegee Institute
University of California, Davis
University of Georgia
University of Illinois
University of Minnesota
University of Missouri
University of Pennsylvania
Washington State University

**Indicates schools requiring three years of university work for admission.
All others require four years and presumably an A.B. or B.S. before
admission to the Medical Technology Program.

APPENDIX B

**DEPARTMENTAL AFFILIATIONS OF
MEDICAL AND DENTAL RESPONDENTS**

Department	Number	Department	Number
Administrative	17	Neurology and Neurosurgery	2
Anatomy (including Histology)	51	Obstetrics and Gynecology	4
Basic Science and Human Biology	7	Pathology	34
Biochemistry (including Physiol. Chem.)	45	Pediatrics	7
Dentistry (including Medical Technol.)	19	Pharmacology	16
Dermatology	1	Physiology and Biophysics	49
Genetics	1	Psychiatry	4
Medicine and Dental Medicine	34	Surgery (including Orthopedics)	10
Microbiology	28		

APPENDIX C

I. TOTAL RESPONSE

Intercept Number*	A	B	C	D	R**	Intercept Number*	A	B	C	D	R**
1	101	<u>239</u>	54	144	1.6	41	62	<u>233</u>	34	210	0.7
2	96	<u>223</u>	36	184	1.4	42	65	<u>228</u>	40	205	0.7
3	31	<u>182</u>	60	<u>267</u> *	-0.2	43	62	<u>249</u>	31	191	1.0
4	94	201	27	<u>214</u>	1.2	44	40	<u>224</u>	30	<u>240</u>	0.3
5	73	<u>235</u>	31	199	1.0	45	73	<u>252</u>	42	169	1.2
6	159	<u>255</u>	58	65	3.9	46	157	<u>187</u>	85	102	2.0
7	53	<u>232</u>	75	181	0.3	47	102	<u>234</u>	67	126	1.5
8	61	165	43	<u>269</u>	0.2	48	59	<u>243</u>	48	181	0.7
9	57	193	48	<u>232</u>	0.3	49	<u>203</u>	<u>174</u>	126	29	2.5
10	156	<u>200</u>	93	81	2.1	50	162	<u>221</u>	90	63	2.6
11	170	<u>179</u>	97	80	2.2	51	129	<u>206</u>	135	61	1.2
12	<u>280</u>	<u>192</u>	43	21	11.3	52	156	<u>192</u>	37	147	2.7
13	<u>293</u>	85	136	7	3.5	53	162	<u>212</u>	100	58	2.3
14	75	<u>220</u>	89	147	0.6	54	168	<u>187</u>	139	32	1.8
15	83	<u>214</u>	147	86	0.4	55	<u>243</u>	<u>88</u>	172	16	1.9
16	117	<u>250</u>	39	128	2.5	56	<u>229</u>	151	115	36	3.0
17	<u>289</u>	86	135	5	3.5	57	<u>210</u>	172	107	40	3.0
18	<u>187</u>	150	161	32	1.5	58	<u>173</u>	160	155	40	1.4
19	54	177	<u>185</u>	115	-0.2	59	188	102	<u>200</u>	34	1.0
20	151	<u>178</u>	156	44	1.2	60	<u>319</u>	122	62	32	8.0
21	<u>213</u>	<u>162</u>	112	44	2.8	61	121	<u>198</u>	134	85	0.9
22	<u>251</u>	168	88	25	4.8	62	248	<u>114</u>	140	22	2.7
23	61	<u>181</u>	166	126	-0.1	63	171	145	<u>174</u>	36	1.2
24	66	<u>192</u>	143	135	0.1	64	157	<u>179</u>	137	60	1.4
25	<u>203</u>	114	192	14	1.3	65	98	184	<u>187</u>	58	0.3
26	<u>138</u>	158	<u>199</u>	38	0.6	66	113	166	<u>197</u>	45	0.4
27	50	159	<u>184</u>	136	-0.3	67	114	128	<u>236</u>	42	0.1
28	121	124	<u>257</u>	28	0.1	68	<u>181</u>	162	144	33	1.8
29	<u>227</u>	124	<u>161</u>	19	2.0	69	<u>196</u>	129	188	18	1.3
30	<u>159</u>	142	<u>197</u>	37	0.8	70	<u>148</u>	156	<u>191</u>	31	0.8
31	106	138	<u>214</u>	73	0.1	71	<u>188</u>	140	172	25	1.4
32	78	157	<u>196</u>	100	-0.05	72	155	138	<u>190</u>	43	0.8
33	165	135	<u>200</u>	34	0.8	73	143	<u>162</u>	160	55	1.0
34	190	129	<u>192</u>	18	1.2	74	72	<u>215</u>	93	148	0.5
35	<u>197</u>	144	131	60	1.9	75	163	<u>116</u>	<u>205</u>	23	0.8
36	<u>134</u>	173	<u>179</u>	40	0.8	76	83	158	<u>182</u>	100	0.1
37	<u>313</u>	110	71	44	6.3	77	55	<u>211</u>	81	183	0.2
38	<u>175</u>	<u>191</u>	96	73	2.4	78	130	158	<u>170</u>	67	0.7
39	83	166	<u>170</u>	111	0.1	79	135	130	<u>198</u>	61	0.5
40	109	148	<u>209</u>	55	0.2	80	66	176	<u>197</u>	90	0.1

* Largest Class underlined

$$** R = \frac{4A+B}{2C+D} - 1$$

II. SCHOOLS OF DENTAL MEDICINE

Intercept Number*	A	B	C	D	R**	Intercept Number*	A	B	C	D	R**
1	21	<u>43</u>	11	35	1.2	41	14	<u>45</u>	8	44	0.7
2	16	<u>48</u>	5	41	1.2	42	15	<u>38</u>	10	<u>47</u>	0.5
3	9	<u>35</u>	15	<u>52</u>	-0.1	43	15	<u>47</u>	7	42	0.9
4	18	41	3	<u>47</u>	1.1	44	8	<u>47</u>	6	<u>48</u>	0.3
5	15	<u>49</u>	5	39	1.2	45	14	<u>53</u>	8	35	1.1
6	36	<u>44</u>	8	20	4.2	46	28	<u>37</u>	12	29	1.8
7	16	<u>47</u>	14	34	0.8	47	20	<u>43</u>	12	34	1.1
8	11	<u>37</u>	8	<u>55</u>	0.1	48	11	<u>44</u>	11	42	0.4
9	14	<u>41</u>	11	39	0.6	49	<u>41</u>	<u>33</u>	25	7	2.5
10	30	<u>33</u>	16	27	1.6	50	38	<u>47</u>	16	9	3.9
11	<u>40</u>	35	18	12	3.1	51	27	<u>38</u>	28	15	1.1
12	<u>51</u>	43	8	6	10.2	52	32	<u>41</u>	7	31	2.8
13	<u>58</u>	14	28	3	3.2	53	<u>40</u>	32	25	9	2.2
14	15	<u>45</u>	20	29	0.5	54	31	33	<u>34</u>	5	1.2
15	21	<u>47</u>	26	12	1.0	55	<u>44</u>	14	<u>40</u>	2	1.3
16	21	<u>65</u>	1	20	5.8	56	<u>45</u>	25	26	9	2.4
17	<u>57</u>	16	28	0	3.4	57	<u>41</u>	29	26	8	2.2
18	<u>49</u>	14	34	5	1.9	58	<u>33</u>	<u>33</u>	<u>33</u>	6	1.3
19	<u>12</u>	<u>43</u>	36	17	0.02	59	34	19	<u>45</u>	6	0.6
20	<u>42</u>	<u>26</u>	31	5	1.9	60	<u>62</u>	21	<u>15</u>	7	6.3
21	<u>40</u>	33	29	<u>5</u>	2.1	61	<u>30</u>	30	<u>35</u>	14	0.8
22	<u>43</u>	39	20	<u>3</u>	3.9	62	<u>50</u>	16	<u>32</u>	3	2.2
23	<u>11</u>	35	<u>42</u>	20	-0.2	63	32	26	<u>37</u>	7	0.9
24	13	<u>34</u>	<u>33</u>	25	-0.1	64	28	32	<u>34</u>	12	0.8
25	38	<u>20</u>	<u>45</u>	3	0.8	65	19	34	<u>37</u>	17	0.2
26	27	26	<u>45</u>	9	0.4	66	18	31	<u>41</u>	12	0.1
27	9	34	<u>41</u>	25	0.3	67	22	27	<u>45</u>	11	0.1
28	18	26	<u>57</u>	4	-0.2	68	<u>36</u>	31	29	9	1.6
29	<u>39</u>	26	36	6	1.3	69	<u>43</u>	25	34	1	1.9
30	31	29	<u>40</u>	7	0.8	70	28	<u>37</u>	35	3	1.0
31	24	32	<u>42</u>	10	0.4	71	34	<u>27</u>	<u>35</u>	8	1.1
32	17	30	<u>41</u>	20	-0.04	72	28	30	<u>40</u>	6	0.7
33	25	32	<u>44</u>	5	0.4	73	30	29	<u>31</u>	13	1.0
34	33	27	<u>41</u>	4	0.8	74	14	<u>38</u>	23	32	0.2
35	<u>35</u>	33	28	12	1.5	75	27	<u>28</u>	<u>40</u>	7	0.6
36	<u>32</u>	27	<u>37</u>	8	0.9	76	16	28	<u>44</u>	19	-0.1
37	<u>49</u>	34	14	13	4.6	77	8	<u>40</u>	23	37	-0.1
38	<u>28</u>	<u>38</u>	21	22	1.3	78	15	<u>34</u>	<u>38</u>	18	0.0
39	14	<u>33</u>	29	<u>33</u>	-0.02	79	20	30	<u>42</u>	15	0.1
40	15	31	<u>43</u>	15	-0.1	80	12	<u>38</u>	36	21	-0.1

* Largest Class underlined

$$** R = \frac{4A + B}{2C + D} - 1$$

III. SCHOOLS OF MEDICINE

Intercept Number*	A	B	C	D	R**	Intercept Number*	A	B	C	D	R**
1	22	<u>108</u>	27	48	0.9	41	18	<u>100</u>	12	79	0.7
2	30	<u>98</u>	10	69	1.4	42	14	<u>102</u>	16	76	0.5
3	5	<u>75</u>	18	<u>109</u>	-0.3	43	19	<u>105</u>	12	69	0.9
4	15	<u>83</u>	11	<u>97</u>	0.2	44	6	<u>96</u>	13	93	0.01
5	9	<u>96</u>	15	88	0.1	45	20	<u>101</u>	17	68	0.8
6	50	<u>120</u>	27	11	3.9	46	42	<u>96</u>	28	40	1.8
7	14	<u>93</u>	37	64	0.1	47	22	<u>113</u>	16	53	1.4
8	9	<u>55</u>	13	<u>130</u>	-0.4	48	15	<u>101</u>	23	67	0.4
9	5	<u>70</u>	24	<u>104</u>	0.4	49	60	<u>77</u>	65	5	1.3
10	46	<u>94</u>	46	<u>18</u>	1.5	50	52	<u>91</u>	51	15	1.6
11	44	<u>83</u>	42	35	1.2	51	33	<u>98</u>	63	14	0.6
12	<u>110</u>	<u>84</u>	11	4	20.4	52	45	<u>79</u>	12	66	1.9
13	<u>82</u>	43	73	2	1.5	53	64	<u>86</u>	45	12	2.4
14	<u>27</u>	<u>90</u>	34	51	0.7	54	54	<u>78</u>	65	8	1.1
15	32	<u>81</u>	71	22	0.3	55	70	<u>45</u>	<u>81</u>	5	0.9
16	34	<u>99</u>	12	62	1.7	56	71	<u>73</u>	50	11	2.2
17	<u>94</u>	34	69	3	1.9	57	75	<u>79</u>	44	9	2.9
18	53	57	<u>84</u>	13	0.6	58	57	<u>74</u>	69	8	1.1
19	16	65	<u>92</u>	31	-0.4	59	56	46	<u>96</u>	7	0.4
20	43	<u>79</u>	69	15	0.6	60	<u>129</u>	51	23	6	9.9
21	<u>74</u>	66	57	8	2.0	61	43	<u>90</u>	56	20	1.0
22	<u>91</u>	67	44	5	3.6	62	<u>79</u>	59	65	4	1.8
23	<u>26</u>	73	<u>77</u>	30	-0.04	63	59	56	<u>84</u>	8	0.7
24	28	<u>75</u>	65	41	0.1	64	60	<u>77</u>	61	12	1.6
25	62	44	<u>92</u>	4	0.6	65	34	67	<u>94</u>	10	0.03
26	42	61	<u>96</u>	9	0.1	66	44	52	<u>97</u>	10	0.1
27	18	60	<u>86</u>	41	-0.4	67	31	42	120	7	-0.3
28	31	44	<u>119</u>	11	-0.3	68	<u>69</u>	61	68	4	1.4
29	<u>80</u>	45	78	4	1.3	69	57	48	<u>99</u>	5	0.4
30	54	45	<u>102</u>	8	-0.1	70	46	56	<u>99</u>	5	0.2
31	35	44	<u>109</u>	19	0.2	71	58	51	<u>89</u>	5	0.5
32	25	51	<u>99</u>	31	-0.3	72	48	51	<u>97</u>	8	0.2
33	58	42	<u>100</u>	6	0.3	73	46	<u>74</u>	72	12	0.7
34	58	52	<u>93</u>	4	0.5	74	24	<u>98</u>	32	53	0.8
35	<u>81</u>	65	51	10	2.5	75	42	48	<u>104</u>	8	0.0
36	35	75	<u>82</u>	14	0.2	76	27	61	<u>85</u>	29	-0.2
37	<u>130</u>	43	<u>29</u>	4	8.1	77	18	<u>88</u>	27	75	0.2
38	<u>75</u>	<u>83</u>	33	14	3.8	78	41	72	<u>80</u>	12	0.4
39	31	<u>70</u>	<u>77</u>	27	0.1	79	48	49	<u>95</u>	11	0.3
40	46	52	<u>93</u>	11	0.2	80	19	70	<u>96</u>	23	-0.3

* Largest Class underlined

** $R = \frac{4A+B}{2C+D} - 1$

IV. SCHOOLS OF VETERINARY MEDICINE

Intercept Number*	A	B	C	D	R**	Intercept Number*	A	B	C	D	R**
1	15	<u>19</u>	6	6	3.4	41	10	<u>20</u>	3	12	2.3
2	<u>21</u>	<u>15</u>	3	7	6.6	42	<u>18</u>	<u>17</u>	5	5	4.9
3	<u>6</u>	<u>22</u>	6	12	0.9	43	<u>5</u>	<u>22</u>	3	15	1.0
4	<u>20</u>	<u>18</u>	3	5	7.9	44	7	<u>27</u>	1	10	3.6
5	<u>15</u>	<u>23</u>	0	8	9.4	45	4	<u>27</u>	1	13	1.9
6	24	<u>14</u>	6	2	6.9	46	<u>21</u>	<u>4</u>	19	0	1.3
7	1	<u>29</u>	4	12	0.6	47	<u>13</u>	<u>14</u>	<u>16</u>	1	1.0
8	14	<u>22</u>	3	7	5.0	48	6	<u>25</u>	0	14	2.5
9	16	<u>20</u>	4	6	5.0	49	<u>19</u>	11	15	0	1.9
10	13	<u>18</u>	10	4	1.9	50	<u>6</u>	<u>26</u>	9	4	1.3
11	<u>20</u>	<u>13</u>	10	1	3.4	51	8	<u>16</u>	<u>18</u>	2	0.3
12	<u>29</u>	5	10	0	5.0	52	<u>20</u>	<u>17</u>	3	5	7.8
13	<u>19</u>	5	<u>19</u>	0	1.1	53	<u>19</u>	11	14	0	2.1
14	<u>9</u>	<u>19</u>	<u>12</u>	5	0.9	54	<u>18</u>	9	<u>18</u>	0	1.2
15	7	<u>15</u>	<u>18</u>	5	0.05	55	<u>17</u>	5	<u>22</u>	0	0.7
16	<u>21</u>	12	<u>10</u>	2	3.4	56	<u>20</u>	6	<u>17</u>	1	1.5
17	<u>19</u>	5	<u>20</u>	0	1.0	57	<u>24</u>	8	13	0	3.0
18	13	9	<u>21</u>	1	0.4	58	<u>13</u>	6	<u>23</u>	1	0.2
19	5	12	<u>20</u>	8	-0.3	59	14	1	<u>28</u>	0	0.02
20	14	8	<u>22</u>	0	0.5	60	<u>32</u>	3	10	0	5.6
21	<u>27</u>	8	8	0	6.2	61	<u>17</u>	12	14	2	1.7
22	<u>31</u>	5	8	0	7.1	62	<u>18</u>	2	<u>23</u>	1	0.6
23	8	14	<u>15</u>	8	0.2	63	13	7	<u>23</u>	1	0.3
24	10	11	<u>19</u>	6	0.2	64	<u>18</u>	6	<u>18</u>	2	1.1
25	16	5	<u>24</u>	0	0.4	65	<u>8</u>	6	<u>29</u>	2	-0.4
26	13	7	<u>24</u>	1	0.2	66	10	10	<u>23</u>	2	0.04
27	7	7	<u>17</u>	14	-0.3	67	7	6	<u>30</u>	2	-0.5
28	8	7	<u>30</u>	1	-0.4	68	15	6	<u>22</u>	1	0.5
29	18	5	<u>22</u>	0	0.8	69	<u>20</u>	4	<u>19</u>	2	1.1
30	16	9	<u>18</u>	3	0.9	70	<u>17</u>	8	<u>17</u>	3	1.1
31	9	10	<u>19</u>	7	0.2	71	<u>21</u>	6	<u>18</u>	1	1.4
32	12	9	<u>19</u>	5	0.3	72	<u>18</u>	5	<u>21</u>	1	0.8
33	16	6	<u>22</u>	1	0.6	73	16	9	<u>18</u>	1	1.0
34	<u>20</u>	3	<u>20</u>	2	1.0	74	6	<u>19</u>	6	12	0.8
35	<u>24</u>	11	8	3	4.6	75	16	<u>2</u>	<u>25</u>	0	0.3
36	<u>18</u>	6	<u>20</u>	0	1.0	76	6	14	<u>19</u>	3	-0.1
37	<u>33</u>	5	<u>5</u>	2	10.4	77	7	<u>22</u>	7	8	1.3
38	<u>23</u>	12	7	3	5.1	78	16	6	<u>20</u>	2	0.7
39	<u>7</u>	<u>18</u>	14	6	0.4	79	12	7	<u>24</u>	1	0.1
40	9	<u>12</u>	<u>21</u>	2	0.1	80	7	14	<u>20</u>	2	0.0

* Largest Class underlined

$$** R = \frac{4A+B}{2C+D} - 1$$

V. SCHOOLS OF MEDICAL TECHNOLOGY

Intercept Number*	A	B	C	D	R**	Intercept Number*	A	B	C	D	R**
1	2	8	0	<u>17</u>	-0.1	42	1	6	1	<u>18</u>	-0.5
2	3	10	0	<u>14</u>	0.6	43	2	6	1	<u>17</u>	-0.3
3	1	2	2	<u>22</u>	-0.8	44	1	3	2	<u>20</u>	-0.7
4	5	10	0	<u>11</u>	1.7	45	3	10	1	<u>12</u>	0.6
5	4	9	0	<u>13</u>	0.9	46	6	8	1	<u>11</u>	1.5
6	7	<u>15</u>	0	<u>5</u>	7.6	47	8	7	1	<u>10</u>	2.2
7	1	3	1	<u>22</u>	-0.7	48	1	9	1	<u>15</u>	-0.2
8	3	7	0	<u>17</u>	0.1	49	6	<u>12</u>	2	6	2.6
9	2	7	0	<u>18</u>	-0.2	50	2	8	1	<u>15</u>	-0.1
10	5	<u>11</u>	1	<u>10</u>	1.6	51	6	8	2	<u>10</u>	1.3
11	7	8	1	<u>11</u>	1.8	52	<u>11</u>	7	0	8	5.4
12	<u>12</u>	11	2	3	7.4	53	6	<u>13</u>	0	6	5.2
13	<u>21</u>	3	3	2	20.8	54	9	<u>10</u>	1	4	6.7
14	2	8	1	<u>16</u>	-0.1	55	<u>16</u>	6	1	3	13.0
15	<u>13</u>	8	4	2	5.0	56	<u>10</u>	<u>12</u>	0	4	12.0
16	6	<u>13</u>	1	7	3.1	57	<u>14</u>	9	0	3	20.7
17	<u>19</u>	4	2	1	15.0	58	<u>10</u>	9	1	4	7.2
18	<u>18</u>	7	1	1	25.3	59	4	<u>13</u>	0	10	1.9
19	9	<u>13</u>	2	1	8.8	60	<u>13</u>	9	1	4	9.2
20	<u>12</u>	8	3	1	7.0	61	3	8	3	<u>12</u>	0.1
21	7	<u>11</u>	2	7	2.5	62	<u>13</u>	8	2	2	9.0
22	<u>11</u>	<u>10</u>	2	3	6.7	63	6	<u>12</u>	1	6	3.5
23	2	<u>13</u>	1	10	0.8	64	2	<u>13</u>	1	10	0.8
24	2	<u>13</u>	2	9	0.6	65	3	<u>12</u>	1	8	1.4
25	<u>14</u>	<u>11</u>	0	0		66	2	<u>16</u>	2	4	2.0
26	8	<u>14</u>	0	3	14.3	67	<u>10</u>	8	2	4	5.0
27	3	<u>13</u>	3	5	1.3	68	6	<u>11</u>	1	7	2.9
28	<u>13</u>	<u>10</u>	2	1	11.4	69	9	<u>12</u>	2	3	5.9
29	<u>11</u>	<u>11</u>	0	3	17.3	70	6	<u>13</u>	3	5	2.4
30	5	<u>14</u>	2	5	2.8	71	6	<u>18</u>	1	2	9.5
31	<u>12</u>	9	2	1	10.4	72	2	<u>18</u>	2	5	1.9
32	5	<u>10</u>	2	7	1.7	73	7	<u>13</u>	2	4	4.1
33	6	<u>14</u>	3	3	3.2	74	0	<u>13</u>	3	9	-0.1
34	<u>11</u>	<u>11</u>	1	0	26.5	75	7	<u>11</u>	1	1	6.8
35	<u>19</u>	5	1	0	39.5	76	2	8	5	<u>11</u>	-0.2
36	4	<u>14</u>	2	6	2.0	77	3	8	0	<u>14</u>	0.4
37	<u>16</u>	<u>9</u>	2	0	17.2	78	3	<u>13</u>	2	7	1.3
38	2	<u>19</u>	2	4	2.4	79	4	<u>11</u>	4	4	1.2
39	6	<u>12</u>	4	3	2.3	80	3	<u>9</u>	4	<u>9</u>	0.2
40	8	<u>9</u>	3	3	3.6						
41	2	6	0	<u>17</u>	-0.2						

* Largest Class underlined

$$** R = \frac{4A+B}{2C+D} \cdot 1$$

VI. SCHOOLS OF NURSING

Intercept Number*	A	B	C	D	R**	Intercept Number*	A	B	C	D	R**
1	12	<u>16</u>	3	8	3.6	41	5	<u>13</u>	7	<u>13</u>	0.2
2	5	<u>13</u>	8	12	0.2	42	6	<u>13</u>	6	<u>13</u>	0.5
3	3	<u>6</u>	6	<u>22</u>	-0.5	43	9	<u>17</u>	6	<u>5</u>	2.1
4	9	<u>17</u>	3	9	2.5	44	8	<u>13</u>	5	11	1.1
5	8	<u>18</u>	3	9	2.3	45	<u>13</u>	<u>11</u>	8	7	1.7
6	12	<u>14</u>	6	5	2.6	46	<u>19</u>	6	11	2	2.4
7	7	<u>16</u>	6	9	1.1	47	<u>16</u>	7	8	6	2.2
8	3	<u>10</u>	11	<u>14</u>	-0.4	48	9	<u>15</u>	6	7	1.7
9	10	8	4	<u>17</u>	0.9	49	<u>23</u>	9	5	1	8.2
10	<u>17</u>	12	3	5	6.3	50	<u>20</u>	9	4	4	6.4
11	<u>14</u>	9	9	4	2.0	51	<u>20</u>	11	3	1	12.0
12	<u>20</u>	15	3	0	14.8	52	12	<u>15</u>	4	6	3.5
13	<u>29</u>	9	2	0	30.2	53	10	<u>15</u>	7	5	1.9
14	9	11	3	<u>14</u>	1.4	54	<u>16</u>	<u>11</u>	7	3	3.4
15	1	<u>19</u>	5	<u>10</u>	0.2	55	<u>26</u>	6	6	0	8.2
16	8	<u>13</u>	4	<u>13</u>	1.1	56	<u>24</u>	7	6	1	6.9
17	<u>28</u>	8	3	0	19.0	57	<u>15</u>	12	6	5	3.2
18	<u>17</u>	<u>17</u>	2	2	13.2	58	<u>15</u>	12	6	5	3.2
19	1	7	7	<u>23</u>	-0.7	59	<u>22</u>	8	5	2	7.0
20	11	<u>15</u>	7	<u>6</u>	2.0	60	<u>21</u>	12	4	2	8.6
21	<u>15</u>	11	6	7	2.7	61	9	<u>14</u>	7	8	1.3
22	<u>20</u>	10	6	3	5.0	62	<u>26</u>	8	3	1	15.0
23	0	9	9	<u>19</u>	-0.8	63	<u>14</u>	<u>14</u>	6	4	3.4
24	3	11	8	<u>16</u>	-0.3	64	<u>14</u>	<u>11</u>	7	6	2.4
25	<u>18</u>	14	6	1	5.6	65	9	<u>16</u>	6	5	2.1
26	<u>15</u>	13	6	4	3.6	66	10	<u>16</u>	9	2	1.8
27	2	8	11	<u>17</u>	-0.6	67	8	<u>14</u>	9	6	0.9
28	12	12	<u>15</u>	0	1.0	68	<u>12</u>	<u>12</u>	9	4	1.7
29	<u>19</u>	15	5	1	7.3	69	<u>21</u>	13	4	1	9.8
30	13	<u>17</u>	7	2	3.3	70	<u>13</u>	<u>13</u>	9	3	2.1
31	4	<u>15</u>	8	12	0.1	71	<u>19</u>	7	9	2	3.2
32	2	<u>17</u>	8	11	-0.1	72	<u>17</u>	6	8	6	2.4
33	11	<u>17</u>	6	5	2.6	73	6	<u>14</u>	11	7	0.3
34	<u>17</u>	<u>15</u>	5	1	6.6	74	5	11	9	<u>13</u>	0.0
35	3	13	6	<u>15</u>	-0.1	75	<u>21</u>	8	7	1	5.1
36	17	<u>17</u>	8	2	2.4	76	9	<u>11</u>	7	10	1.0
37	<u>19</u>	9	6	5	4.0	77	5	<u>16</u>	5	11	0.7
38	5	<u>12</u>	7	11	0.9	78	<u>16</u>	12	2	7	5.9
39	1	9	12	<u>16</u>	-0.7	79	<u>11</u>	<u>11</u>	7	9	1.4
40	10	7	<u>17</u>	6	0.2	80	5	<u>13</u>	10	8	0.2

* Largest Class underlined

$$** R = \frac{4A + B}{2C + D} - 1$$

VII. SCHOOLS OF PHARMACY

Intercept Number*	A	B	C	D	R**	Intercept Number*	A	B	C	D	R**
1	27	<u>29</u>	7	19	3.2	41	9	<u>35</u>	4	34	0.7
2	19	<u>33</u>	4	26	2.2	42	8	<u>38</u>	2	34	0.8
3	5	<u>33</u>	10	<u>34</u>	-0.02	43	5	<u>36</u>	2	<u>37</u>	0.4
4	19	24	7	<u>32</u>	1.2	44	6	25	3	<u>47</u>	-0.1
5	16	29	5	<u>33</u>	1.2	45	10	<u>37</u>	5	29	1.0
6	23	<u>32</u>	10	<u>17</u>	2.4	46	<u>32</u>	25	11	14	3.2
7	6	<u>30</u>	12	<u>35</u>	-0.1	47	18	<u>35</u>	12	17	1.6
8	15	24	6	<u>35</u>	0.8	48	11	<u>36</u>	7	28	0.9
9	7	34	4	<u>36</u>	0.4	49	<u>35</u>	28	10	9	4.8
10	<u>28</u>	24	16	14	2.0	50	24	<u>36</u>	8	13	3.6
11	<u>32</u>	22	12	15	2.8	51	<u>25</u>	<u>25</u>	15	17	1.7
12	<u>43</u>	21	8	8	7.0	52	<u>33</u>	20	8	23	2.9
13	<u>66</u>	5	9	0	13.9	53	18	<u>41</u>	7	19	2.4
14	8	<u>36</u>	16	23	0.2	54	30	<u>35</u>	10	9	4.3
15	7	<u>30</u>	21	25	-0.1	55	<u>52</u>	8	17	5	4.5
16	23	<u>35</u>	10	14	2.7	56	<u>48</u>	18	11	8	6.0
17	<u>56</u>	<u>10</u>	10	1	10.1	57	<u>31</u>	27	13	10	3.2
18	30	<u>33</u>	13	8	3.5	58	<u>35</u>	18	19	11	2.2
19	9	<u>30</u>	23	22	-0.03	59	<u>43</u>	12	21	6	2.8
20	23	<u>28</u>	21	12	1.2	60	<u>51</u>	17	5	9	10.6
21	<u>45</u>	21	8	7	7.7	61	17	<u>33</u>	16	17	1.1
22	<u>44</u>	26	5	7	10.9	62	<u>50</u>	9	14	8	4.8
23	12	<u>26</u>	19	<u>26</u>	0.2	63	<u>36</u>	20	21	5	2.5
24	8	<u>34</u>	13	28	0.2	64	28	<u>32</u>	13	9	3.1
25	<u>48</u>	10	19	0	4.3	65	21	<u>34</u>	17	10	1.7
26	<u>32</u>	22	23	5	1.9	66	<u>27</u>	26	21	8	1.7
27	11	<u>28</u>	21	19	0.2	67	<u>34</u>	17	25	5	1.8
28	<u>33</u>	<u>16</u>	26	5	1.6	68	<u>39</u>	23	10	7	5.6
29	<u>50</u>	12	16	1	5.4	69	<u>39</u>	13	26	3	2.1
30	<u>38</u>	15	24	3	2.3	70	<u>33</u>	15	25	6	1.6
31	19	18	<u>31</u>	11	0.3	71	<u>47</u>	13	16	4	4.6
32	15	<u>28</u>	25	15	0.4	72	<u>38</u>	16	18	9	2.7
33	<u>46</u>	<u>13</u>	21	3	3.4	73	<u>34</u>	17	24	3	2.0
34	<u>44</u>	8	28	1	2.2	74	20	<u>27</u>	17	16	1.1
35	<u>34</u>	11	32	3	1.2	75	<u>43</u>	5	25	0	2.5
36	<u>29</u>	21	26	4	1.4	76	21	<u>31</u>	18	11	1.4
37	<u>59</u>	10	11	3	8.8	77	14	<u>29</u>	17	20	0.6
38	<u>36</u>	18	21	6	2.4	78	<u>32</u>	<u>14</u>	26	9	1.3
39	22	19	<u>28</u>	11	0.6	79	<u>36</u>	16	23	6	2.1
40	19	26	<u>28</u>	6	0.6	80	17	26	<u>28</u>	11	0.4

* Largest Class underlined

$$** R = \frac{4A + B}{2C + D} - 1$$

APPENDIX D

COMBINED DENTAL AND MEDICAL FACULTIES

Intercept	Combined Faculties	Doctorate Date		Doctoral Type		Nature of Teaching	
		1950	1950	M.D.*	Ph.D.	Basic	Clinical
1	1.0	1.0	0.8	0.9	0.9	1.2	0.7
2	1.4	1.7	0.9	1.4	1.1	1.5	1.1
3	-0.3	-0.2	-0.3	-0.2	-0.3	-0.3	-0.2
4	0.1	0.2	0.7	1.0	-0.03	0.3	0.6
5	0.4	0.4	0.4	0.6	0.2	0.5	0.3
6	4.0	5.2	3.0	3.9	3.9	4.6	3.4
7	0.3	0.4	0.2	0.4	0.1	-0.1	0.7
8	-0.2	-0.5	0.0	-0.1	0.4	-0.4	-0.1
9	-0.1	-0.2	-0.1	0.0	-0.3	-0.1	-0.2
10	1.6	2.1	1.1	1.4	1.6	1.5	1.5
11	1.7	1.9	1.6	1.4	2.1	1.2	2.3
12	15.7	17.3	12.7	12.8	17.6	24.7	10.3
13	2.0	2.0	2.0	1.7	2.3	1.6	2.3
14	0.6	0.8	0.5	0.6	0.6	0.4	0.9
15	0.5	0.7	0.3	0.6	0.5	0.2	0.8
16	2.6	2.8	2.4	3.1	2.2	1.7	3.9
17	2.3	2.5	2.0	2.0	2.5	2.1	2.4
18	1.0	1.2	0.6	1.1	0.6	0.7	1.0
19	-0.3	-0.1	-0.4	-0.2	-0.4	-0.4	-0.2
20	1.0	1.1	1.0	1.3	0.8	1.0	1.0
21	2.0	3.1	1.3	1.6	2.5	2.1	1.9
22	3.7	5.4	2.6	3.5	3.9	4.0	3.5
23	-0.1	-0.1	-0.2	-0.1	-0.1	-0.02	-0.2
24	0.05	0.2	0.0	0.2	-0.1	0.2	-0.02
25	0.7	0.6	0.7	0.8	0.5	0.5	0.9
26	0.2	0.3	0.2	0.3	0.2	0.2	0.3
27	-0.4	-0.4	-0.3	-0.3	-0.4	-0.5	-0.2
28	-0.3	-0.3	-0.2	-0.2	-0.4	-0.3	-0.2
29	1.3	1.3	1.4	1.6	1.1	0.9	1.8
30	0.1	0.2	0.6	0.7	0.2	0.3	0.6
31	-0.06	-0.2	0.2	0.2	-0.2	-0.2	0.1
32	-0.2	-0.4	-0.03	0.1	-0.5	-0.3	-0.1
33	0.4	0.1	0.7	0.6	0.2	0.3	0.5
34	0.6	0.4	1.0	0.9	0.4	0.5	0.9
35	2.1	2.1	2.5	2.4	2.2	2.3	2.4
36	0.4	0.7	0.4	0.8	0.2	0.6	0.4
37	6.7	5.9	7.9	7.2	1.5	8.1	5.7
38	2.7	2.9	2.7	2.7	2.9	3.2	2.4
39	0.0	-0.1	0.2	0.2	-0.02	0.3	-0.2
40	0.1	0.1	0.1	0.1	0.2	0.5	-0.1
41	0.7	0.7	0.6	1.0	0.3	0.4	1.0
42	0.5	0.4	0.5	0.4	0.5	0.4	0.5
43	0.9	0.9	1.1	1.9	0.3	0.5	1.5
44	0.1	0.01	0.2	0.6	-0.2	-0.2	0.6
45	0.9	0.9	1.0	1.3	0.6	0.4	1.6
46	1.8	2.1	1.6	1.7	1.9	1.6	2.0
47	1.3	0.6	2.1	2.3	0.6	0.6	2.1
48	0.4	0.3	0.6	0.8	0.1	0.1	0.8
49	1.7	1.6	1.9	2.1	1.4	1.6	1.8
50	2.2	2.1	2.3	3.1	1.5	1.5	3.1
51	0.8	0.7	0.9	0.8	0.9	0.6	1.0
52	2.2	2.3	2.1	2.9	1.6	1.7	2.6

Intercept	Combined Faculties	Doctorate Date		Doctoral Type		Nature of Teaching	
		1950	1950	M.D.*	Ph.D.	Basic	Clinical
53	2.3	2.6	2.2	2.4	2.4	2.5	2.2
54	1.1	1.2	1.2	1.2	1.2	1.3	1.1
55	1.1	1.0	1.3	1.2	1.0	0.8	1.4
56	2.3	3.1	1.9	2.6	2.2	2.0	2.8
57	2.6	3.1	2.3	3.0	2.4	3.0	2.4
58	1.1	1.0	1.4	1.3	1.1	1.5	0.9
59	0.4	0.2	0.8	0.7	0.3	0.4	0.5
60	8.4	12.6	5.6	7.8	8.6	10.0	6.8
61	0.9	0.8	1.1	1.2	0.7	1.0	0.9
62	1.9	2.2	1.9	1.9	2.1	1.8	2.1
63	0.7	0.6	0.8	0.6	0.9	0.7	0.8
64	1.3	1.5	0.9	0.6	1.9	1.6	0.8
65	0.1	-0.04	0.3	0.3	-0.05	0.2	0.05
66	0.1	0.01	0.3	0.2	0.1	0.3	0.03
67	-0.2	-0.3	-0.1	-0.1	-0.3	-0.3	-0.03
68	1.5	1.9	1.2	1.2	1.9	1.5	1.6
69	0.7	0.8	0.8	1.3	0.3	0.3	1.4
70	0.4	0.4	0.5	0.9	0.1	0.1	0.9
71	0.7	0.8	0.8	0.9	0.7	0.5	1.2
72	0.3	0.2	0.5	0.5	0.2	0.1	0.6
73	0.8	0.6	1.0	1.3	0.4	0.6	1.1
74	0.5	0.7	0.3	0.4	0.5	0.8	0.2
75	0.2	0.2	0.2	0.2	0.2	0.0	0.4
76	-0.1	-0.1	-0.1	-0.2	-0.04	-0.1	-0.1
77	0.1	0.1	0.1	0.1	0.1	0.4	-0.1
78	0.2	0.4	0.2	0.2	0.4	0.3	0.3
79	0.3	0.1	0.3	0.1	0.3	0.2	0.2
80	0.2	-0.3	-0.2	-0.2	-0.2	-0.3	-0.2

* Includes those with DMD and DDS degrees and respondents with both M.D. and Ph.D. degrees.

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